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IS RADIUM IN THE SUN?

S. A. MITCHELL.

On its discovery, radium seemed to contradict the laws of matter. Heat and light were given out by radium without it being apparently changed in any manner, and a continuous supply of energy seemed evolved, which thus set at naught the fundamental law of physics, the law of Conservation of Energy. Later, it was learned that the atom, the foundation on which chemistry was reared, was no longer the unchanging particle of matter, for radium seemed to have at last brought to knowledge the philosopher's stone, since one element was transmuted into another.

In the science of physics, a new branch of investigation was opened up by the discovery of radium, and the studies in radioactivity have brought forth some of the noblest triumphs of the human mind. In the science of chemistry, a new conception was given us of the atom, and a new scheme was mapped out for the formation of our fundamental elements.

Such great changes having already been made in both physics and chemistry through the study of radium, what place will astronomy find for Mme. Curie's element? Physics, chemistry and astronomy are bound together in the science of astrophysics. What information will the spectroscope give concerning radium?

The past fifty years of this "New Astronomy" have revolutionized our conceptions of the old astronomy of position. We have found the physical constitution of the sun. We found helium in the sun more than a quarter of a century before Sir William Ramsay discovered it present in the earth. Now will the tables be turned and will we find radium in the sun, now that we know it present in the earth?

Our study of the spectra of the distant stars has brought to our knowledge no new element; the same elements that we know of on earth seem to be present throughout the universe. Rowland has said that if the earth were heated to incandescence, it would give a spectrum

the exact counterpart of that of the sun. A new triumph for the spectroscope has come within the past few months in Fowler's discovery of new series of lines in the spectrum of hydrogen. An interesting line at wave-length 4686 was found in the spectrum of the eclipsed sun and also in the spectra of certain stars. From a study of series of lines, Rydberg was sure that the line 4686 was due to hydrogen. Though this line had never been found in laboratory spectra of hydrogen, though carefully looked for, so plausible were the theoretical predictions that the line has for years been called a hydrogen line. Professor Alfred Fowler of South Kensington has discovered the line in the laboratory, associated with other lines of the same series, and has also discovered an entirely new series of hydrogen lines. In proving that this line was in reality due to hydrogen, Fowler states that it is not necessary to seek new elements to give identification to unknown spectrum lines, and that matter seems to be entirely similar throughout the universe. It is important then to the complete study of radioactivity that its spectral lines be found in other bodies than in the earth. Is radium in the stars? Is it in the nearest fixed star, our own sun? All our ideas of evolution make us believe that since radium is in the earth, it must also be present in the sun and in some, at least, of the stars. But can its presence be proved by lines in solar or stellar spectra?

Before looking into this question more closely, it would be best to review some of the information that radium has brought to science. And to think that after all the whole science of radioactivity is more or less the result of a happy accident! The year following the discovery of the X-rays in 1895 by Röntgen, Becquerel of Paris wished to test the phosphorescent action of certain substances by wrapping a photographic plate in black paper, and placing on it the substance to be examined, which was then exposed to sunlight. By good fortune a preparation of uranium was chosen and the photographic plate was darkened. The Becquerel rays were thus discovered, and it was soon found that, like the X-rays, these rays penetrate substances impervious to light, even passing through thin plates of metal. The experiments were always made by placing the phosphorescent substance in the sunlight on top of the black paper enclosing the photographic plate. But one day the sun was clouded, and the plate and the phosphorescent substance were placed away in a desk and were left there for several weeks. Becquerel for some reason developed the plate and was surprised to find the plate darkened as before, thereby showing that probably neither sunlight nor phosphorescence had anything to do with the action on the photographic plate. Thus was born in 1896 the new property of radioactivity!

Besides the effect on the photographic plate, radioactive substances manifest themselves in three different manners: first, by exciting phosphorescence and fluorescence; second, by causing the air near them to become conductors of electricity; but most startling of all, by the continuous generation of light and heat. The radioactive effects owe their origin to the emission of rays that have been called Alpha, Beta, and Gamma rays. These rays are but the manifestation of a spontaneous and continuous source of energy. Heat and light are given out by radioactive substances year in and year out without these substances being apparently in any way consumed or altered. The most delicate balance known to science cannot detect the slightest loss of weight in a piece of radium even after it has been giving out rays for years. These radioactive substances were therefore apparently performing the scientifically impossible feat of evolving energy from nothing.

Mme. Curie recognized that radioactivity was a property of the atom and starting with this in view found that the residues from the mine at Joachimstal, Austria, were three to five times more radioactive than uranium. From this residue she separated out a new substance far more active than uranium which she called polonium, in honor of the place of her birth. Later she discovered radium. This appears to be an element with atomic weight 226, and it is found in excessively minute quantities, there being only one part in five million of the best pitchblende. In 1899, Rutherford showed that the radiation from uranium was complex, consisting of (1) the α rays, which are absorbed by a sheet of paper or a few centimeters of air, (2) of a hundred-fold more penetrating β rays, capable of passing through several millimeters of aluminium, and (3) of still more penetrating γ rays capable of passing through quite a thickness of iron and lead. The β rays are deflected by a magnetic field. Becquerel and Kaufmann showed that the β rays were negatively charged particles projected with a velocity approaching that of light. The very penetrating γ rays are not deflected in a magnetic or electric field, and are probably closely connected with X-rays.

Though the α rays are the least penetrating, they are much the most important of the the three types of radiation. They are deflected much less by a powerful magnetic field than the β rays, and in the opposite direction, showing that the α rays consist of a stream of positively charged particles. Alpha rays, therefore, will affect a gold leaf electroscope, and this old instrument gives one of the most sensitive methods of measuring the amount of radiation. In fact, Rutherford has shown that it is not difficult to measure with certainty the presence of radium in a body which contains as small a quantity as 10^{-11} grams of radium!

The maximum velocity of the α rays is 12,000 miles per second. They cannot be detected by any means, photographic or electrical, when they

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The maximum velocity of the α rays is 12,000 miles per second. They cannot be detected by any means, photographic or electrical, when they

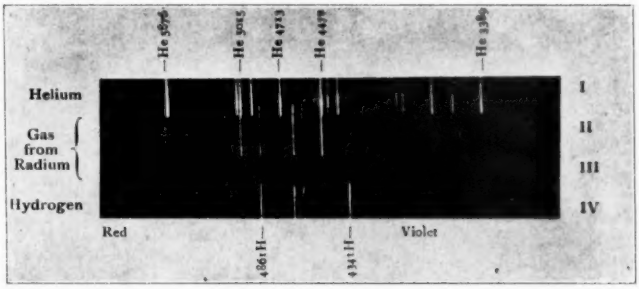
move as slowly as 5000 miles per second. The α rays move with velocities hundreds of times greater than the fastest moving meteor. Everyone is aware of the enormous energy possessed by a meteor moving, say, at 40 miles per second. But energy varies as the square of the velocity, and thus the α particle of radium possesses a quarter of a million times more energy, mass for mass, than a swiftly moving meteor. In this enormous energy of the α rays lies the secret of the surprises of radium. From whence comes this enormous store of energy?

In addition to its power of sending out radiations, radium possesses another important property, shared in by the radioactive substances actinium and thorium, namely that of continuously emitting a radioactive "emanation" or gas. This property is rendered very striking if a specimen of radium bromide is dissolved in water and the liquid evaporated down to dryness again to get the solid substance. This simple process has caused the radium to lose the greater part of its radiation. Strangely enough the radium slowly regains its activity, and if left entirely to itself, at the end of a month it is as radioactive as ever. Rutherford has showed that the solution in water causes the radium to give off a gas called "radium emanation." This emanation has all the properties of a true gas, which can be liquified at a temperature of —150° C, but it is 100,000 times more radioactive weight for weight than radium. It does not combine with any known substance, and is not acted upon by any chemical reagent. It is not a radium compound, but it is a new element with an atomic weight which appears to be 222. It takes its place along with the rare gases of the air, argon, helium, neon, etc., and it gives a characteristic bright-line spectrum which shows neither the radium nor helium lines. It seems, therefore, that the element radium has been transformed into another element, radium emanation. If after a month, the radium is again dissolved in water and evaporated to dryness as before, the radium loses its activity, and a fresh crop of emanation is produced. This same process may be repeated as often as possible with the result always the same, and we are perforce compelled to assume that the radium is continually manufacturing emanation, continually changing itself into a new element. This is really only the first of a series of changes for Radium Emanation changes into Radium A, and this in turn to Radium B, and so on. This change is an atomic change going on within the atom. But how does this change progress?

When the radium has given off the emanation, it still gives out α particles, but only about one-fourth as copiously as before the radium was put in water. The α particles are produced by the same change as makes the emanation, and the radium atom is therefore divided into emanation and α particle.

Observations of the velocity and mass of the α particle have been made by Rutherford. The ratio of the charge carried by the particle to its mass $\left(\text{denoted by } \frac{e}{m}\right)$ is for the α particle from radium 5070, which is found to be the same for the α particles from all kinds of radio-active material, showing that these α particles have a single mass for all substances. The value of $\frac{e}{m}$ for the hydrogen atom is 9660, or about twice that for the α particle. This would indicate that the mass of the α particle is twice that of the hydrogen atom, or if the charge carried by the α particle is twice that of the hydrogen atom, then the mass of the α particle is four times that of the hydrogen atom and must therefore be an atom of helium. Hence each atom of radium apparently breaks up into one atom of helium and one of radium emanation.

All that was necessary to complete Rutherford's proof that helium was given off from radium was to show experimentally that helium was thus produced. This was accomplished in 1903 by Sir William Ramsay and Frederick Soddy. A tube was filled with radium emanation which was separated from all other gases by condensing it with liquid air and removing by a pump the gas not condensed. This spectrum tube was sealed and the spectrum of the gas could be examined at will. At first



COMPARISON OF THE SPECTRA OF HELIUM, HYDROGEN AND RADIUM EMANATION.

no helium lines were visible, but after a lapse of three or four days, when the radium emanation had disintegrated, the spectrum of helium gradually made its appearance, and finally the whole helium spectrum was complete. In the accompanying illustration is given Dr. Giesel's photograph of the production of helium from radium. I represents the spectrum of helium, IV that of hydrogen, II the spectrum from radium after an exposure of twenty minutes, III the same after five minutes In II, the spectrum from radium emanation (and therefore, the spectrum from radium, since emanation is produced from radium) are the lines

due to helium, showing conclusively that helium is produced from radium. Similarly, Debierne has found by the spectroscope that helium is produced from the radioactive substance actinium, and Soddy has produced helium from uranium and thorium. Helium, therefore, has been found experimentally to be produced by the radioactive substances radium, thorium, uranium and actinium. These substances are alike in that each emits α particles. Hence, α particles are atoms of helium. Rutherford and Royds, however, have given a still more conclusive proof that the α particle is an atom of helium. These α particles are capable of penetrating a certain small but definite thickness of glass. Glass may be blown very thin but yet retain its ability to remain air tight. Radium emanation was stored in such a thin-walled vessel and this enclosed in a second vessel. Alpha particles given off from the radium emanation thus could penetrate through the very thin glass walls, but were stopped in the outer vessel and were there collected. At first the gas in the outer vessel was found to contain no helium, but after some days, helium lines appeared, proving beyond a question of doubt that radium gives off helium.

It is even possible to measure the rate of growth of the helium, which measures show that in a year 168 cubic millimeters of helium are spontaneously manufactured by each gram of radium. Rutherford and Geiger in this connection achieved one of the greatest triumphs for experimental science in being able to count the number of helium molecules or atoms that are ejected per second from one gram of radium. Indeed two different methods were devised which led to the same results. Both methods depend on the fact that each atom of helium as it is ejected gives a small flash like a meteor. By an electrical method, these flashes were counted by Rutherford and Geiger and it was found by them that thirty-four thousand million (3.4×10^{10}) atoms of helium are ejected every second from each gram of radium. This number is in exact agreement with that obtained by noting with a microscope the number of scintillations on a given area in a given time by the spinthariscope, which was invented by Sir William Crookes. Thus at the same time there was measured the amount of helium produced from radium, and likewise was given the number of molecules present in matter, information which was needed to complete many theories in physics.

Radium thus produces helium and radium emanation. But the division of atoms does not end here. Radium emanation produces helium and Radium A. In turn are produced Radium B, Radium C, Radium D, Radium E, and Radium F, which seems identical with Polonium discovered by Mme. Curie. Finally, Radium G is produced. It seems very probable (though the proofs are not conclusive) that this is an atom of lead. The products emanation, Radium A, B, etc. have each

different periods of existence. Radium emanation is half transformed in 3.9 days, Radium A in the short space of time of three minutes. Even radium itself is transitory, but its period of existence is much greater and amounts to as much as 1760 years. Consequently, it must itself be produced by some other element. The ancestor of radium seems probably to be uranium, which has the long life of five thousand million years.

Investigations in radioactivity have given an entirely new conception of the atom. The atom is no longer one and indivisible, but certain atoms at least are transformed into other atoms, each radium atom being changed into one atom of helium and one of radium emanation. These atoms are continually changing, no less than thirty-four thousand million atoms of helium being produced each second of time from each gram of radium. As the atoms disintegrate, enormous stores of energy are let loose, and this energy manifests itself as light and heat. The heating effect of this energy has been measured and has been found to be 118 gram calories per hour per gram of radium. A specimen of a grain of radium bromide would evolve about four calories per hour. In four years about 140,000 calories would have been evolved. An equal weight of coal would during complete combustion give out about 500 calories. Hence, the radium in four years would give 280 times as much heat as if it had been coal and had been completely burned, and yet the radium in this time would diminish so very little in weight that it would be absolutely impossible to detect this diminution by the most sensitive balance known to modern science. The energy of radium comes from the disintegration of its atoms. A quantity of radium would take 1760 years to disintegrate, so that in the complete life of a grain of radium about 100,000,000 calories are set free, This is 200,000 times more energy than if it were pure coal and entirely burned!

As radium disintegrates, it produces helium and radium emanation. The latter itself disintegrates very rapidly compared with radium, so that in a body a state of "radioactive equilibrium" must exist between radium and radium emanation whereby the latter must disintegrate in quantities at the same speed as it is produced. From the transformation times, it is readily seen that in such a state of equilibrium, there must be over 100,000 times more radium than radium emanation. Helium being permanent and not transitory, must accumulate as the result of radioactive changes. In these changes Soddy has shown the remarkable sensitiveness of the spectroscope in detecting slight quantities of helium for he has proved in numerous special experiments, that the D_3 line of the helium spectrum can be detected with certainty, if one millionth of a cubic centimeter, or one five-thousand-millionth part of a gram of helium is present.

Let us now apply these new ideas to problems in astronomy, and let us think of the sun and earth. First of all, the disintegration of the atom gives a form of energy new to our conceptions, which is of an order a million times greater than any form of energy known to us previously. To explain the enormous heat of the sun, it would be necessary only to postulate that it was rich in radioactive materials, and that consequently, enormous stores of energy are set free as heat by radioactive changes. If Mars needs to be warmed up in order that the Martian canals may consist of water, it is only necessary to imagine that in the process of evolution Mars is rich in radioactive matter and that the temperature on Mars in consequence, instead of being far below zero Fahrenheit, as certain physical theories tell us, is above the freezing point of water. Many ingenious applications may be made of the new energy let loose by radium.

On the earth and in the sun, we are forced to the conclusion that where radioactive minerals exist there must transformation have proceeded for thousands and millions of years. Helium being permanent and not transitory must accumulate with the lapse of time, and it must be present in all radioactive minerals. This is found to be true. On the other hand, radium emanation, for instance, being a quickly transforming substance can be present only in such infinitesimal quantities that it could not be detected even by the delicate spectroscope.

Eclipse spectra since 1868 have told us that helium is present in the sun. If it has had its origin as the result of radioactive changes, then must radium be in the sun, and likewise the parent of radium, uranium. From what has already been stated, we could not expect to find the lines of radium emanation in the sun's spectrum.

As is well known, no helium lines are found in the ordinary or Fraunhofer spectrum of the sun. Helium is readily seen in the chromosphere, and its lines are found in the spectrum of the chromosphere at the time of an eclipse. No radium or uranium lines are found in the solar spectrum; are they in the chromosphere spectrum? The lines in the solar spectrum are dark because the sun's chromosphere is at a lower temperature than the photosphere; but at a total eclipse when the moon covers up the sun's surface the chromosphere, being very hot, will give a spectrum of bright lines. The change from dark-line spectrum to bright-line spectrum was foretold by Young for the eclipse of 1870, and was called by him the "Flash Spectrum."

So much interest has been created by radium investigations that more than a passing comment was made on observations of Dr. Giebeler and Professor Küstner of Bonn, published in *Astronomische Nachrichten* 4582, who pointed out remarkable coincidences between the lines in the spectrum of Nova Geminorum 2 and those due to radium, radium

emanation and uranium. These observations were confirmed by no less an authority than Professor Kayser.

Following this in *A. N.* 4589, the Astronomer Royal of England, Dr. F. W. Dyson, made a comparison with the chromosphere lines obtained by him from observations of the eclipses of 1900, 1901 and 1905, and with the chromosphere lines obtained by Sir Norman Lockyer at the eclipse of 1898, and drew the following conclusion, "It seems to me that these lines in the chromosphere may reasonably be attributed wholly or partially to radium."

At the eclipse of 1905, while a member of the United States Naval Observatory expedition at Daroca, Spain, I was fortunate in getting photographs of the "Flash Spectrum" by means of a Rowland grating ruled on a parabolic surface, and used as an objective grating without slit. Excellent definition, with normal spectrum having a dispersion of 1 mm = 10 Å. U., permitted the determination of wave-lengths whose errors are but a few hundredths of an Ångström unit. A comparison with my wave-lengths will supplement Dyson's results in *A.N.* 4589.

The chromosphere spectrum was first compared with the spectrum of radium as given in the 1912 edition of Exner and Haschek, where the wave-lengths are in substantial agreement with those of Runge and Precht. The intensities in the arc and spark are added. The probable origins of the eclipse lines are given where the intensity in the sun is taken from Rowland's tables, and the intensities in arc and spark from Exner and Haschek, except the *Ti*-line at 3814.70 which is taken from Lockyer's list of enhanced lines.

Radium Spectrum Exner and Haschek				Chromosphere Spectrum			
				Mitchell		Dyson	
Line	Wave-Length	Intensities		Wave-Length	Int.	Wave-Length	Int.
		Ark	Spark				
1	3649.74	3	3	3649.70	0	3649.66	1
2	3814.61	50	50	3814.67	3	3814.67	6
3	4340.82	20	5	4340.63	75	*Hγ*	100
4	4436.50	5	1	4436.35	2	—	—
5	4533.35	10	3	4533.34	2d	—	—
6	4641.48	5	—	—	—	—	—
7	4682.41	100	50	4682.12 4682.58	2 2	4682.20	2
8	4699.47	5	1	4699.52	1	—	—
9	4826.10	30	10	—	—	—	—

Line	Probable Origin of Chromosphere Lines				
	Rowland	Element	Intensities		
			Sun	Arc	Spark
1	3649.65	*Fe, La*	5	*Fe* 3 *La* 2	3 1
2	3814.70	*Ti-Fe*	8	*Ti* 2 *Fe* 2	5 1
3	4340.63	*Hγ*	20	—	—
4	4436.31	*V, Gd*	0	*V* 5 *Gd* 4	5 10
5	4533.32	*Ti* —	5	20	5
6	—	—	—	—	—
7	4682.09 4682.53	*Ti* *Y-Co*	3 1	10 *Y* 4 *Co* 10	6 10 4
8	4699.51	*V, Sa*	4	*V* 2 *Sa* 3	1 2
9	—	—	—	—	—

Concerning the coincidences the following may be said:

1. This line may reasonably be identified with the line at 3649.65 due to *Fe* and *La*. The intensity in the sun is 5.

2. Identified with the blended line in the sun, intensity 8, of *Fe* and enhanced *Ti*.

3. Would be covered by *Hγ*.

4. The line 4436.50 differs too much in wave-length from 4436.35 to be due to the same origin. Chromosphere line erroneously identified by Lockyer as *Mn*-line at 4436.52.

5. A close double in the flash spectrum identified with a blended line in the sun. This line not found in Dyson.

6. 4641.48 of the same intensity in the radium arc as 4436.50. Is not found in my spectra nor in Dyson's.

7. The strongest line in the radium spectrum falls between two lines in the chromosphere, the first fully identified as a *Ti*-line, the second as a combination of *Co* and enhanced *Y*.

8. Of the same intensity in arc spectrum of radium as lines 4 and 6. The line in the chromosphere fully identified.

9. The third strongest line in the radium spectrum. If it is present in the chromosphere, it must be very faint.

In identifying lines in two spectra, one must have in mind more than the agreement in wave-length of certain lines. There is such a vast number of lines in the solar spectrum that one might almost be able to assume a spectrum at will of any dozen wave-lengths, and find these matched very closely by lines in the sun. The wave-lengths, however, must match exactly and not approximately; but unfortunately, this has often-times been forgotten. Helium has an atomic weight less than any other element except hydrogen. On this account the lines of both

hydrogen and helium are very strong in the spectrum of the chromosphere. Hydrogen being very light extends high up above the photosphere, measures of the 1905 spectra showing that the hydrogen envelope is 14000 kilometers (8000 miles) high. Helium stretches up at least half this distance.

On the other hand radium is very heavy, having an atomic weight of 226, being heavier than gold, mercury or lead. Consequently, one would not expect a radium atmosphere to extend very high above the sun's photosphere, and as the moon progressively moves in front of the sun at the time of the total eclipse, the radium envelope would be exposed for a very short time, while hydrogen and helium would be exposed for comparatively long times. As a result one would expect in photographs of flash spectra taken without a slit that the hydrogen and helium lines would be long and dense, while the radium lines would be short and faint. Hence, if there is radium in the sun we should expect to find only the stronger spectral lines at wave-lengths 4682, 3814, 4826, 4340, and 4533. By looking at the table, we see that all but the line at 4826 are satisfactorily identified with other lines in the sun. Even if 4826 were present in the spectrum of the chromosphere, it must of necessity be a feeble line. A spectroscopist would scarcely try to prove that radium is in the sun from the presence of one feeble line. It is unfortunate that there are so many apparent coincidences between the lines in the radium spectrum and those in the chromosphere.

A comparison was likewise made with the lines of radium emanation with the result that there are no lines in the chromosphere which may be regarded as being due to radium emanation. A similar comparison with similar results was made with the uranium spectrum.

From theoretical considerations we are positively convinced that there must be radium in the sun. But to prove this is another problem! With the spectra we already have, we can prove nothing more than accidental coincidences. One of the problems for the total eclipse of August, 1914, will be to obtain the spectrum of the chromosphere on a large scale with good definition, so that we may prove what we think we know, that radium is present in the sun.

Yerkes Observatory.
March 1913.

THREE HUNDRED YEARS OF RESEARCH ON THE MOTIONS OF THE SATELLITES. 1610-1910.

KURT LAVES.

[*Continued from page 291.*]

What LeVerrier and Simon Newcomb had accomplished for the motions of the planets around the sun, viz., a complete test of Newton's universal law of gravitation, had yet to be done for the systems of satellites. On the basis of Souillart's theory, A. Marth constructed tables for the four satellites, by means of which their geocentric positions can be found with ease and accuracy. By their help micrometer measurements of the satellites could now be utilized for the improvement of the fundamental constants on which the theory was built. A. Marth over and over again called attention to the fact that Souillart's adoption of Damoiseau's Constants was the weak part of his theory and that some large observatory should, by means of an heliometer, measure distances and position angles of the four satellites in a systematic manner.

It was Sir David Gill who responded to Marth's promptings. His long experience with the powerful Capetown heliometer made him exceptionally able to carry out this plan and with the assistance of Professor Finlay he secured during 1890-91 a large set of excellent measures of the four satellites. The reduction of these observations and their comparison with the theory of Souillart was entrusted some years later to Mr. W. de Sitter then an assistant at the Capetown observatory. He took this for the subject of his Ph. D. thesis and published an excellent discussion of the observations in the year 1901 in Groningen. From this discussion trustworthy data concerning the inclinations and nodes of the satellites were secured; furthermore the coefficients of certain short-period inequalities were obtained, which such a series of heliometric observations, extended over about three or four months, could grant. Professor de Sitter soon realized that the limited series of observations which he had discussed would not suffice to cope with the problem and himself undertook in 1901-1904 another series of observations with the Capetown heliometer at a time best adapted to evaluate certain quantities. For others, for example the determination of the nodes of II on Jupiter's plane, it was necessary to fall back on the observations of eclipses made at times as far remote as possible from the epoch of the heliometric observations.

The matter seemed now to attract wider interest and on the advice of Sir David Gill the late B. Cookson made an independent set of observations both by the heliometer and by the photographic method. His careful and very able discussion of these observations appeared with papers of Professor de Sitter in volume XII of the Annals of the Cape Observatory. In them photographic observations made at Poulkova and Helsingfors are likewise reduced and utilized. A rather interesting result by Professor Sitter deserves special mention. His observations indicate a larger amplitude of the librational angle about the mean value 180° than had followed from Delambre's or Damoiseau's discussions. If this proves to be real, an additional equation will be available which involves the masses of the three satellites.

The Cape observers had hardly finished their new measurements when the news of the discovery of a fifth satellite by Professor Barnard with the aid of the 36-inch Lick refractor was communicated to the scientific world. This satellite circles in such close proximity to the central body that it takes but twelve hours to complete its circuit. Its eccentricity and inclination to Jupiter's equator are quite small, nevertheless, as the very careful discussions of its orbit by Professor F. Cohn, now the director of the Berliner Jahrbuch office, and by Professor Struve have shown, the advance of the line of apsides by about 916° and the recession of the line of nodes by the same amount have been determined with a fair degree of accuracy. The four Galilean satellites are too far away from V to give rise to any appreciable inequality. Their combined effect will advance the line of apsides by 0°.5 a year. The perturbative action of Jupiter's ellipticity which brings about both the advance of the line of apsides and the recession of the line of nodes is given in the analytical theory by a power series of which in the case of V two terms will have to be taken into consideration; on account of their greater distance from the primary but one term need be considered in the case of the other satellites. The determination of the two coefficients which these terms introduced into the problem is possible from two equations, the first coefficient will best be determined from the motion of the line of nodes of the second satellite (II) and the second from that of V. These coefficients are highly important quantities, since by them the physical conditions of Jupiter's make up as a whole are revealed. The oblateness of Jupiter and of those planets which are accompanied by satellites is derived from the motion of their satellites with a much higher degree of accuracy than any micrometrical measures are able to give.

The fifth satellite will perhaps be the last satellite to be discovered by direct eye observation. The success which Professor Pickering had with the photographic method in the case of the two new satellites of

Saturn inspired Professor Perrine at Lick to try a similar search in the case of Jupiter. In 1905 and 1906 he discovered the sixth and seventh satellites, the orbits of which seems to coincide, moreover they intersect each other so that rather interesting dynamical questions will be proposed for solution. Two years later the eighth satellite was discovered by Mr. Melotte of Greenwich and a relatively large number of photographic measures were gathered by the Greenwich observers owing to an ingenious method of extrapolation from previous observations by which the approximate place of VIII was known in advance. This satellite takes almost two years to complete its circuit about Jupiter; its orbit is marked by an unusually large eccentricity and a likewise large inclination to the planet's orbital plane; as in the case of Phoebe its motion is retrograde. At the time of apojovium the satellite will not be very far away from the sphere of activity of the planet so that the question has been raised whether or not VIII will always continue to be a satellite of Jupiter. The shift of the line of nodes of the orbit on that of its primary is about 3° a year and the line of apsides will show a similar change. Inclination and longitude of node will reveal a behavior similar to that which the corresponding quantities of Japetus have shown, and Laplace's explanation of the disturbing influence of the sun will be directly applicable. Accurate measurements of the elongations of VIII will in the future lead to the best determination of the mass of Jupiter. This important constant is so intimately connected with the theory of Jupiter's satellites that it seems but proper to devote some attention to it here.

Newton was the first to urge the determination of Jupiter's mass from a discussion of measured elongations of the fourth satellite. Halley's observations yielded the value 1033 for the reciprocal of the constant. Pond and after him Triesnecker secured by their improved instruments an increased accuracy. Their values were 1066 and 1048 respectively. This result of Triesnecker is not the one which he found but one which came out of a new discussion of his excellent observations by Professor Schur. When Laplace had published his theories of the motions of Jupiter and Saturn, it was but natural to attach great importance to the value deprived from the perturbations which Saturn suffers by the perturbative action of Jupiter. Bouvard's value came out rather small, the reciprocal being 1070. Some doubts were entertained as to the accuracy of this result, when Nicolai and Encke determined this constant close to 1050 from perturbations of Jupiter on Juno and Vesta. For some time the doubt was expressed, whether the method of perturbations could really be expected to give the same result as the measurements of the elongations of satellites. Santini, Airy, Bessel and Jacob lent their energies to settle this rather puzzling problem. All of

them made independently of each other new measurements of the elongations of IV and after careful discussion united nearly on values close to 1048. We will quote Bessel's value 1047.90 in particular, since it was based upon the observations of IV made with the excellent heliometer of the Koenigsberg observatory and since Bessel's superior mastery of problems of this kind at once gave to his value a kind of finality, acceded to only very few investigators in his day.

The small planets which move in orbits close to that of Jupiter afford a good determination, since the point-like appearance of their discs permit micrometric measurements of great accuracy. Thalia, Themis Egeria and Amphitrite were used for this purpose by the following investigators: Schubert, Krueger, Hansen and Becker. Their values differed by less than a unit from Bessel's value, with the exception of Hansen who found 1051.1. The observations of the comets of Faye and Encke were further data well adapted to the evaluation of this constant. Moeller and von Asten derived values 1047.8 and 1050.5. From two distinct modes of approach practically the same value for the mass of Jupiter was thus obtained. In the future it was necessary to settle only the decimal part of this number. To this end Schur attacked the same problem in close conformity with Bessel's mode of observation His observations made with the Göttingen heliometer extended over four years. Besides, a new discussion of Triesnecker and Bessel's observations was undertaken by him. Combining Bessel's and Schur's determinations the value 1047.568 was obtained which is based on the elongations of all of the four satellites. Newcomb adopts the final value of 1045.35 ± 0.065 in his "Astronomical Constants" in which all of the values previously attained are subjected to a critical examination. The heliometric observations of the Cape Observatory differ imperceptably from this value.

The remark was made in the early part of this paper that even the early observations of eclipses of Jupiter's satellites could be made with considerable accuracy. The following comparison of the probable errors of ancient and modern eclipse observations is taken from Professor de Sitter's dissertation:

Satellite	I.	II.	III.	IV.
ancient obser. in time	15s	35s	90s	120s
modern " " "	15s	15s	20s	40s
ancient " geocentric	0″.09	0″.17	0″.34	0″.34
modern " "	0″.09	0″.07	0″.07	0″.11

The probable error of a heliometer observation is 0″.087 so that it is of about the same accuracy as a modern eclipse observation; but this applies only when the determination of those unknowns is considered which do not depend on the observation of the duration of eclipses

The probable error of a photographic observation is even smaller than that of a heliometer observation. It would seem then that for the latitudes of the satellites and therefore for inclination and longitude of nodes, eclipse observations are of small value.

By the introduction of photometric measurements at the time of eclipses Professor E. C. Pickering has given enhanced importance to the observations of eclipses. The moment of time can be obtained with a remarkable precision when the light of the satellite is diminished to half its previous value. A long series of such eclipse observations has been made at the Harvard College observatory from 1878 to 1903 and Professor R. Sampson of Durham University has reduced them and made them the basis of his tables of the four satellites. Damoiseau's eclipse tables gave but a rough approximation for the determination of the configurations of the satellites; transits and occultations were not dealt with. Professor Sampson's tables provide for all the phenomena and furnish the exact coördinates of the satellites at any desired instant. Marth transformed Damoiseau's tables so as to give jovicentric coördinates from which the positions of the satellites with reference to Jupiter or to each other were derived. The new tables of Professor Sampson which have recently been published, furnish jovicentric coördinates, and it is from them that the circumstances of any phenomena are derived. It is important to note that the reductions of photographic measurements will be greatly facilitated by them. The handling of the new tables is by no means an easy matter, notwithstanding the many useful devices which the author has introduced in order to facilitate the manipulations. The new theory of the four satellites will rest practically alone on the evidence furnished by the Harvard results. It is but natural to repeat the wish to which Professor Innes has given expression in Volume 33 of the Observatory, that the ancient data and the modern Cape observations and other available material could all have been included in the final theory of the four satellites.

In closing the discussion of Jupiter's satellites the reader's attention is once more called to the fact that the Lagrange-Laplace-Souillart theory furnishes the foundation for the explanation of the motions of the four satellites. For the determination of the unknowns which depend on longitudes and radii vectores, the great mass of visual eclipse observations has given sufficient data, but the visual eclipse observations have proved entirely inadequate for the determination of those quantities which are to be obtained from the latitudes of the satellites. Here the modern heliometric and photographic observations supply the missing data. The photometric observations are probably superior in accuracy to both the heliometric and photographic measurements; they permit the determination of the con-

stants of either category. Considered in this light Professor Sampson's procedure to make his new theory rest solely on a homogeneous set of material of superior quality has after all much to recommend itself to the investigator. Most likely in the near future the Laplace-Souillart method will be replaced by a more adequate method in which the planet's equator will be taken as the plane of reference. It is not unlikely that Professor Griffin's paper in Volume IX of the Transactions of the Mathematical Society of America will furnish a valuable foundation for this new theory.

II. The System of Saturn's Satellites.

In the same year (1610) in which Galileo discovered the four satellites of Jupiter he saw for the first time the rings of Saturn. In his rather imperfect instrument they appeared as two round appendages on either side of the planet. As time went on, they gradually diminished in brightness till at the end of 1612 both had vanished completely. This phenomenon, for which Galileo could find no possible explanation, caused him most painful mental troubles, as is evidenced by a letter which he wrote to Welser in 1612. We quote from Grant's translation. "Has Saturn devoured his own children? Or were the appearances indeed an illusion or fraud, with which the glasses have so long deceived me as well as many others, to whom I have shown them? I do not know what to say in a case so surprising, so unlooked for, and so novel. The shortness of the time, the unexpected nature of the event, the weakness of my understanding, and the fear of being mistaken, have greatly confounded me." The statement has been made that the keen disappointment which the rings of Saturn gave to Galileo kept the great scientist from continuing his observations on Saturn. Otherwise he would most likely have discovered that the disappearances of the rings are closely related to Saturn's period of revolution around the sun.

The next fifty years brought this fact to light, and a number of theories were invented to explain the peculiarities which the observations showed. Of these Roberval's conception of vaporous emanations above the torrid part of Saturn's surface and their reflection of the sun's light approached the truth to some degree; but it postulated that these emanations of Saturn should at two points of its orbit be very vigorous while at points 90° from them they should cease completely. Such a theory could evidently not suffice. To the keen insight of Huyghens is due the true explanation of the phenomenon. In the form of a logogriph, 7a 5c 1d 5e 1g 1h 7i 4l 2m 9n 4o 2p 1q 2r 1s 5t 5u, as was customary in those days, he first communicated his solution and gave later (1659) the proper restoration of the letters as follows:—"annulo cingitur, tenui plano, nusquam cohaerente ad eclipticam inclinato:"—

"The planet is surrounded by a slender flat ring, everywhere separated from Saturn's surface, and inclined to the ecliptic." Huyghens's explanation rests consistently on the following facts of observations and laws of motion:

1.—All the primary bodies rotate about fixed axes.

2.—The satellites—like those of Jupiter—move about the same axis and their periods are the longer the farther away they are from the primary.

Since at the time of Huyghens's observations in 1655 the appendages appeared as a line through Saturn's center and did not change their position from day to day, he concluded that they must have the form of a ring and be located in the planet's equator. The equator being inclined considerably to the plane of the ecliptic, Huyghens's simple postulate of a ring in the equatorial plane easily explained all the observed phases of Saturn. His theory was practically adopted when in 1671, at the time of Saturn's passage through the node of the ring, the appendage disappeared temporarily just as he had predicted. The time of his forecast was inaccurate to the extent of two months, since a determination of the longitude of the ascending node of the plane of the ring on the ecliptic rested on the previously observed times of disappearance. These observations were not made with sufficient accuracy before the days of Huyghens. The inclination of the plane of the rings to the ecliptic and the longitude of the ascending node were determined by Bessel in 1834 by means of continued measurements with the Koenigsberg heliometer and by a very skillful discussion of the times of disappearance and reappearance of the rings since 1701. This determination of Bessel was fundamental for the foundation of a consistent theory of the motions of the satellites.

Huyghens most likely thought of Saturn's rings as an assemblage of closely packed moonlets circulating about their primary and not as a solid disk of matter. Indeed his fortunate discovery of a first satellite of Saturn in 1655 falls, in time, before his announcement of his logogriph, and one can well imagine that it gave rise and substance to his ingenious form of explaining the phases of Saturn's appendages The satellite which he discovered is Titan, so called later by Sir John Herschel because it exceeds all others in mass.

Great attention was brought to the study of Saturn in 1671, the year of the discovery of the second satellite, Japetus, by T. D. Cassini. Its period is close to 80 days while that of Titan is but 16 days. It is interesting to note that the variability in the light of Japetus, which is such a marked characteristic of this satellite, caused Cassini entirely to lose sight of it in the early days of December 1671. Fortunately by the use of a more powerful instrument of 34 feet focal length he was able, a

year later, to rediscover it. This was on the 13th of December 1672; a few days afterward the satellite again disappeared and could not be found for a number of months although the weather conditions were favorable. Cassini's persistent search for the satellite made him scrutinize very carefully a small star which was not far from the place where Japetus was expected to be. This star turned out to be a new satellite, whose period was but $4\,^1/_2$ days. When one considers the clumsy and unmanageable instruments which were used in those days of the long-focus refractors, the results achieved by the perseverance of Cassini are really remarkable. Nor was he satisfied with the results obtained. By the year 1684 he had in his possession at the observatory at Paris object glasses of 100 and 136 feet focal length and with these a new search for satellites was instituted, as soon as the decreasing opening of the ring would present favorable conditions for observation. In March 1684 two more satellites were discovered by him, both so close to the planet that their periods were but 1.8 and 2.7 days. No more satellites were found for more than a century; then the era of reflecting telescopes, instituted by W. Herschel, gave a new harvest in this field as in others. On the 28th of August 1789, W. Herschel had the good fortune to have in the field of his reflector not only the five satellites, which Huyghens and Cassini had discovered but also a sixth satellite whose period proved to be smaller than those of the rest. The observations of the innermost satellite required the most powerful telescopes and excellent atmospheric conditions.

In the art of constructing reflectors which was so singularly advanced in England during the first half of the nineteenth century, Lassell had a very prominent part. By means of a 2-foot reflector he was able to observe the very tiny eighth satellite Hyperion. By a strange coincidence W. Bond of Cambridge observed the same object with the new 13-inch refractor on the very same night, September 19, 1845. Both of the observers had seen the object on a previous night, and needed the second observation for establishing the reality of their discovery. Since Bond's first observation preceded by two days Lassell's first observation, it is but fitting to give him primarily the credit of this discovery.

Hyperion is peculiarly an "American" acquisition, since through the skillful observations of A. Hall and Newcomb's mathematical ingenuity the peculiar motion of Hyperion was first revealed to astronomy. The discovery of satellites IX and X by Professor W. Pickering in the years 1898 and 1904 is rather recent history. Phoebe, IX, circles at the very outskirts of Saturn's system in retrograde motion whilst Themis, X, is in close proximity to Titan and Hyperion. Both are bound to prove interesting objects for the future. Of the detail which the rings

of Saturn revealed to the observers we have not spoken, since our interest is centered on the motion of the satellites.

When Laplace published the fourth volume of his Mécanique Céleste he gave but scant attention to the satellites of Saturn. This, as he pointed out, was due to the fact, that very few observations were available in his days; one fact stood out very prominently even then, viz. while the orbits of all the satellites seemed to coincide with Saturn's equator, the orbit of Japetus (then the most remote of Saturn's satellites) showed a perceptible difference in inclination which proved to be variable. Laplace recognized at once in the perturbative action of the sun the cause of this anomaly. While this perturbation is insignificant even in the case of the orbits of Dione and Titan, it gains importance in the case of Japetus, owing to its greater remoteness from Saturn. We need but refer to our remarks concerning the fourth satellite of Jupiter, where the same cause gains prominence.

It is one of Bessel's greatest achievements to have brought about by his own single-handed efforts, within less than twenty years, such a complete change in our knowledge of the motions of Saturn's satellites that at his death their motions were almost as well understood as those of Jupiter's satellites. His work was of a two-fold character; first, he made careful heliometric measurements of Titan and other satellites and also of the ring system and, secondly, he developed the theory of the system of Saturn on the basis of Laplace's general theory. A few trustworthy observations, made during the preceding centuries, were skillfully coupled by him with a masterly discussion of his own observations. From this investigation the elements of Titan came out with such an accuracy that very little had to be added later by Professor H. Struve to make them valid to represent modern observations.

Bessel's "Theorie des Saturnsystems" and his discussion of the orbit of Titan remain to this day the model for the investigator in this field. He wanted the orbit of Titan to be known with the utmost accuracy, since his observations of the other satellites were largely made with reference to Titan and not with reference to the primary. This method has been followed with great success by the modern observers, and we may say that the recent improvements in the theory of Jupiter's system are due to the adoption of this mode of observation. Unfortunately Bessel's death in 1846 left his "Theorie des Saturnsystems" in an unfinished state, and so far his general researches have not been brought to a finish. Although his micrometrical observations were continued by a number of observers, primarily in England, during the next decades, they did not attain the same accuracy nor were they conducted in as systematic a manner as the theory would demand. A new era in this field began when the Washington observers, mainly A. Hall, devoted

their new 26-inch refractor to the study of the satellites of Saturn, and Simon Newcomb unravelled the apparently anomalous motion of Hyperion. His attention was called to this problem by Hall's sagacious interpretation of the observations of Hyperion. Hall had found that the longitude of Hyperion's perisaturnium showed a recession of about 20° per year. Now the ratio of the mean daily motion of Titan to that of Hyperion is very nearly 4 to 3, it was therefore natural to have an eye on those terms of the perturbative functions which contained the argument $4l' - 3l$. Since $4n' - 3n$ amounts in one year to about 18°.8 and the annual increase of $\hat{\omega}'$ is of this magnitude, it follows that in the perturbative function which contains $V' = 4l' - 3l - \hat{\omega}'$ will be an argument which undergoes almost no change in the course of time. It ceases therefore to rank among the periodic terms of the perturbative function and has the rank of a very important secular term. It is called a librational term and V' fulfills a certain differential equation which is of the nature of that characteristic of the motion of an oscillatory pendulum; the value about which V' is oscillating is nearly 180° as is proved by the observations. The perturbation in $\hat{\omega}'$ due to this term permits of a determination of the mass of Titan with relatively great precision. G. W. Hill, F. Tisserand, O. Stone, W. Eichelberger and H. Struve have in turn investigated the motion and improved our knowledge.* So far there is still lacking a satisfactory method which will take into account the eccentricity of Titan.

During the last two decades of the nineteenth century, Professor H. Struve of the Pulkova Observatory undertook a systematic and thoroughgoing investigation of the entire system of Saturn's satellites. Starting with the 15-inch refractor, the mutual distances and position angles of pairs of satellites were most carefully measured from season to season. Likewise the satellites were referred to Saturn's center as a check and for the determination of the mass of the entire system. As soon as the new 30-inch refractor became available for this investigation, the work was continued with this powerful instrument. The inner satellites could now receive special attention and the results obtained speak highly both for the accuracy of the observations and the mathematical skill of the investigator. The results are published in two volumes of the proceedings of the Academy of St. Petersburg. Space does not permit us to give more than a short summary of the advances which these investigations have brought out. The four inner satellites have been shown to form two sub-systems; the first consists of Mimas (I) and Tethys (III), the second is formed by Enceladus (II) and Dione (IV). In both systems the mean daily motion of the inner satellite is very nearly twice that of

* The ingenious method employed by Professor Hill will for future investigations in this field of research prove to be a most valuable model to follow.

the other component, but the two systems themselves seem to have no further interrelation. While the orbits of the components of the first system show a marked inclination to Saturn's equator—the angles are of the order 1° 30′—the other system seems to move in the plane of the equator. On the other hand, while Mimas shows no evidence of eccentricity, Enceladus and Dione have sufficiently elliptic orbits to show an advance of the line of apsides. The recession of the nodes of Mimas and Tethys depends, of course, primarily on the perturbation due to the ellipticity of Saturn; but Professor Struve succeeded in showing that there is further a librational term of the argument $w = 4l' - 2l - \theta - \theta'$ which affects the motion of the line of node of both satellites. In this argument θ and θ' represent the longitudes of the ascending nodes of the two satellites. Since $4n' - 2n$ in a year is equal to 437° and the yearly combined backward motions of the lines of nodes amounts to about 437°, it is seen that the term in the perturbative function which depends on this argument is bound to play an important role in the motion of both satellites. In particular it causes in the mean longitudes a marked librational motion which can be enunciated in the following theorem due to Struve:

The conjunctions of Mimas and Tethys oscillate about the middle-point of that arc of Saturn's equator which lies between the ascending nodes of the orbits of the two satellites. The amplitude of this periodic swing is about 45°, its period nearly 68 years.

From the coefficients of the librational terms in the longitudes of the two satellites, Professor Struve obtained a relative measure of the masses of Mimas and Tethys; the mass of the outer satellites, Tethys, is about fifteen times that of Mimas. When compared with the mass of Saturn, Mimas is about equal to $\frac{1}{11500000}$, Tethys $\frac{1}{750000}$ of Saturn. It is interesting to observe that the librational terms in the motion of the inner satellites of Jupiter are caused by terms in the perturbative function which are of the order of the products of the masses of the satellites, the librational terms in the case of Hyperion-Titan, Mimas-Tethys and Enceladus-Dione depend on the first power of the mass of the perturbing satellite.

In the eighth volume of the Astronomical Journal are given the results of Newcomb's investigation of the motions of two satellites about an ellipsoid of revolution like Saturn, when the mean daily motions of the satellites approach the case of commensurability in the form $\frac{j}{j+1}$ where j is any integral number. For $j = 1$ we shall have the case of the two inner sub-systems, for $j = 3$ the case of Hyperion-Titan. He proves the following interesting theorem:

Under the assumption that the two orbits are originally circular and that the motion of the point of conjunction is feeble in comparison with the motion of the two satellites, then the mutual perturbations of the satellites will originate eccentricities in their orbits and the line of apsides of each orbit will constantly pass through the point of conjunction.

If we examine the motions of Enceladus and Dione in the light of this theorem it will be seen from Professor Struve's observations that actually the assumptions in Newcomb's theorem are fulfilled in the system Enceladus-Dione. The motion of the longitude of the perisaturnium of II (Enceladus) is very nearly 123°, that is to say it is equal to $2n' - n$. If the mass of Dione were zero, the motion of the perisaturnium would have come out to be about 153°, i.e., equal to the motion of the nodes. The observed eccentricities of Enceladus will then directly be a measure of the mass of Dione. Thus m' was found to be $\frac{1}{500000}$ of the mass of Saturn. It will not be out of place to recall the case of Hyperion-Titan and remind the reader that the annual motion of the perisaturnium of Hyperion is equal to $4n' - 3n$ per year the point of conjunction very nearly coincides with the aposaturnium about which it oscillates in a librational form of motion. The amplitude and period of this libration were not determined by Professor G. W. Hill or Newcomb. Since the theory upon which V' depends is not yet in an entirely satisfactory condition, Professor Struve set out to determine the periodic variation of $V' - 180°$ by an empirical formula: $A.\sin\left[\frac{360}{T}(t-t^\circ)\right]$ and found from an extended set of early and recent observations $A = 36°$, $T = 643^d$, $t^\circ = 1887$ March 25. Professor W. Eichelberger had used the long list of observations made at Washington for a similar investigation and besides confirming Professor Struve's results he recognizes further periodic terms in V'. These formulas should next be proved to arise from an analytical demonstration; so far they are simply empirical formulas.

III. The Systems of Satellites of Mars, Uranus and Neptune.

On the 11th and 17th of August 1877 Professor A. Hall discovered the two satellites of Mars. The inner satellite Phobos is so close to the surface of its primary that its distance from it is only about 4000 miles. The time of revolution about Mars is only $7^h\ 39^m$, while the period of Deimos is $30^h\ 18^m$. The observations show that the orbits of both satellites are very little inclined to the equator of the planet. The time of rotation of Mars is well known and likewise its mass, but direct observa-

tions will not yield a trustworthy determination of the ellipticity of the planet. The value of the ellipticity is an important quantity in order to find out whether or not the small inclination to the equator is accidental. Adams and Tisserand have both investigated this problem and have come to the conclusion that for probable values of the ellipticity between $\frac{1}{180}$ and $\frac{1}{220}$ the smallness of the inclination is a natural consequence of the dynamical grip which Mars is exerting on the two satellites. Later investigations have shown that the orbit of Phobos shows an eccentricity and from it an advance of the line of apsides can be obtained. This together with the recession of the line of nodes will make the magnitude of the ellipticity of Mars known with considerable accuracy in the near future.

The two outer satellites of Uranus were discovered by W. Herschel in 1787, their times of revolution are 9 and 13.5 days. In 1851 Lassell found the two inner satellites, with periods of 2.5 and four days. They move very nearly in the same plane and this plane is inclined to the plane of the ecliptic under an angle of 98 degrees. The mass of Uranus can not be determined with accuracy from its perturbations on Saturn and Neptune; by the known times of revolution and measured elongations of the satellites this constant is now known with great precision. There must be a considerable ellipticity of Uranus, otherwise the planes of the orbits of the satellites would not be the same. The very nearly circular form of the orbits of the satellites and the difficulty in observing a recession of the nodes will for some time to come hinder the determination of the ellipticity of Uranus.

Two years after the discovery of Neptune, Lassell found its only satellite. Subsequent observations have shown that it likewise moves in a retrograde direction, the inclination to the ecliptic is 145°, its period of revolution 5 days and 21 hours.

The mass of Neptune is found from the period and elongations of its satellite. Concerning the position of the equator and its ellipticity direct observations will reveal nothing, but here the considerable change of the line of nodes on the ecliptic and the change of the inclination bid fair to grant at some future day trustworthy information concerning these quantities. On account of the remoteness of the sun his perturbing influence on the position of the orbit of Neptune's satellite can well be neglected. The observed motion of the plane must then be explained by the ellipticity of the primary. As is known from Laplace's theory the pole of the satellite's orbit will in the time T move in a small circle about the pole of the equator. In the 65 years elapsed since the discovery of the satellite the node has moved about 13 degrees. A graphic determination of the center from this arc is therefore hardly

accurate enough to inspire much confidence. When T shall be known a measure of the ellipticity of Neptune will be obtained. For the inclination and longitude of node of Neptune's equator on the equator of the earth Tisserand, on the basis of the observations of Professor Struve, has made some preliminary calculations to fix approximately upper and lower limits under reasonable assumptions which are taken from data furnished by the neighbouring planets.

The University of Chicago.
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AN OBSERVATORY FOR VARIABLE STAR WORK

S. C. HUNTER.

To the amateur astronomer one of the greatest puzzles is a satisfactory arrangement of his telescope for easy and efficient observing. In northern latitudes it is not comfortable to stand out in the cold on winter nights, although this is the time when the constellations are most brilliant and interesting. Even without the cold, the physical effort of lugging the instrument out for observing and taking it back again is an unpleasant business and tends to discourage this otherwise pleasant and profitable occupation.

After finally deciding to house my five inch equatorial, the question of just how to do it required careful consideration, and several different plans were suggested. The house with the sliding roof presented many advantages, not the least of which was the moderate cost. As, however, the structure, whatever it was, had to be located in a conspicuous place near my house on the lawn, this did not seem a wise choice, and besides it seemed best to have something that would give better protection from the wind while observing than would be afforded by the sliding roof construction. The time-honored use of a revolving dome for observatory work seemed to justify itself beyond all other appliances after all, and believing that this was the logical solution, the next thing was to find directions for building one on as small a scale as would be required in my case. A diligent search failed to discover any data whatever. It was easy enough to find specifications for the construction of the large and expensive domes that are generally erected in connection with the public observatories located in various places, but the difficulty was to find anything that was simple and comparatively inexpensive in the line of this construction.

I happened to mention the matter to Mr. Leon Barritt, Editor of the Monthly Evening Sky Map, to whom I am indebted for furnishing the lead that brought about the desired result. Mr. Richard E. Schmidt, an architect of Chicago, was working on the same problem and had been corresponding with Mr. Barritt about it. He, like myself, had been unable to find anything in print that could be used to advantage, and

FIGURE 1.

finally he decided to make his own plans and specifications for a wooden dome fifteen feet in diameter. He found the cost of iron or steel practically prohibitive, and was kind enough to send me a full set of his blue prints for such use as I might wish to make of them. These I finally handed over to a ship-builder, who agreed to construct a dome in accordance with Mr. Schmidt's plans for $375, but with a diameter of twelve feet only, this cost to include delivery at my place in New Rochelle, also setting up. The above price, by the way, was from $700 to $800 cheaper than an iron or steel dome of the same dimensions.

Then I had built a circular brick structure, 11 feet 8 inches inside diameter, the walls being 8 inches thick and 6 feet from floor to top tier. This was done at a cost of $100.

The first illustration shows the dome set up before the sheathing was put on over the frame work. It will give a good idea of the brick circle and skeleton construction. The frame work was covered with ordinary 2x1½ tongue and groove sheathing laid on diagonally in short lengths between the frames. Over this heavy canvas was stretched and glued, which with two coats of paint made a perfectly water-tight job.

The second illustration shows the completed observatory from the

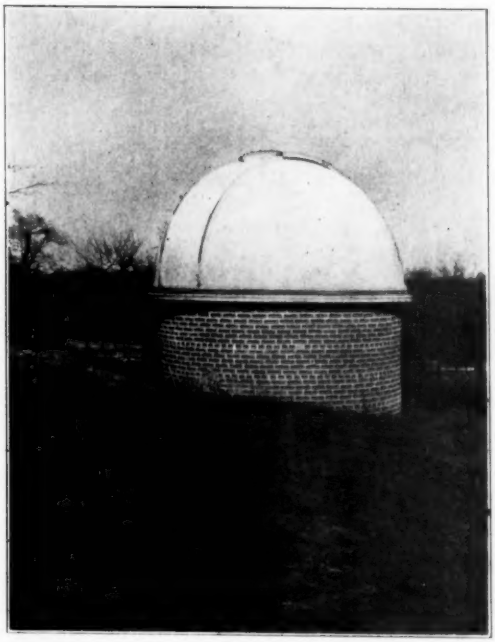

FIGURE 2.

opposite side to which the shutters are attached. The carpenter work, sheathing, canvas, etc. cost $150. The dome was made to revolve by supporting iron wheels three inches in diameter strapped together by iron bands following along either side, these bands being held in place by bolts passed through the wheels. The wheels run in a circular "U" shape iron track top and bottom. A rack installed on the inside with a cogwheel attachment makes it possible to turn the dome with the slightest touch.

The greatest problem of all was the shutters. The usual method of sliding one long shutter sideways did not appeal to me. It meant a draughty interior, particularly when observing against the wind; so I

had the shutters made in three sections like hatch covers, these to slide up and down independently on a brass track, the control being through a system of cords and pulleys on the inside. So far as I have ever heard, this is an entirely novel arrangement, but in actual service it is ideal. It enables one to open just enough to disclose the desired field and observe in any kind of a wind or temperature with comparative comfort, and any segment of the heavens may be observed from the horizon to the zenith, at the same time enough of the opening can be protected by manipulating the sections to make the wind, even when blowing hard, quite negligible. To keep the water out between the sections, the second and third are rigged with tin visors that overlap three or four inches.

FIGURE 3.

The third illustration shows the shutters partially open, as they would be for observing a specific field.

Of course as compared with other housings for small telescopes the total expense is considerable. It amounted in all to about $800, but it has been justified, first by the rather distinguished air it gives to my place, and next by the comfort with which observations can be made.

Besides, I now have a complete amateur observatory of a unique type, and extremely simple to handle. As I found I had more room than was necessary for my five inch instrument, I subsequently exchanged this for an eight inch Clark equatorial which snugly fitted in when mounted.

THREE CENTURIES OF TOTAL ECLIPSES OF THE SUN IN MEXICO. 1850-2150.*

DAVID TODD.

Eclipses are predicted,
And science bows them in.
EMILY DICKINSON.

So wrote the pensive poet of my college town, who herself had never seen an eclipse, and whose knowledge of them was chiefly confined to the certainty of their always happening on time.

To human spectators, whether savage or civilized, scientists or layman, a total eclipse of the sun is most impressive and full of wonder; and awe thereof is accentuated by its taking place at the exact hour, minute and second when the astronomer says it will.

Until the dark body of the moon is actually seen stealing its silent way athwart the brilliant sun, there is always the lurking doubt whether, by some slight error of a tedious astronomical calculation, the eclipse may not after all fail; for nearly an hour after beginning, so bright is the remaining crescent that birds and animals, indeed most human beings, detect no change; under a shady tree the remnant of sunlight filters in a multitude of tiny crescents overlapping; swiftly and silently flitting over the landscape are the delicate, sombre waves of the shadow bands, a sort of "visible wind;" then follows the overpowering rush of the moon's mighty shadow, as if something tangible were sweeping by with incredible celerity. All life is awed into silence. Then, out upon the darkness, gruesome but sublime, flashes the glory of the incomparable corona, a silvery, soft unearthly light, with radiant streamers stretching at times millions of uncomprehended miles into space; while the rosy, flaming protuberances skirt the black rim of the moon in ethereal splendor.

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* From *Resena del XVII Congreso Internacional de Americanistas* (Congreso del Centenario), Mexico, 1912.

"Nature stands aghast;
And the fair light which gilds this new-made orb,
Shorn of his beams, shrinks in."

Astronomers everywhere tell off the time, ply the pencil, click the camera; minutes fly as if seconds; savages dance and shout and beat their tomtoms. Then keen as a flash comes the first arrow of returning sunlight; corona and prominences melt into the sky once more; the swiftly receding shadow may be glimpsed if one looks quickly from a mountain height. The great occasion has come and gone; a superb sight of which Langley, a studious observer of many eclipses, has well said, "The spectacle is one of which though the man of science may prosaically state the facts, perhaps only the poet could render the impression."

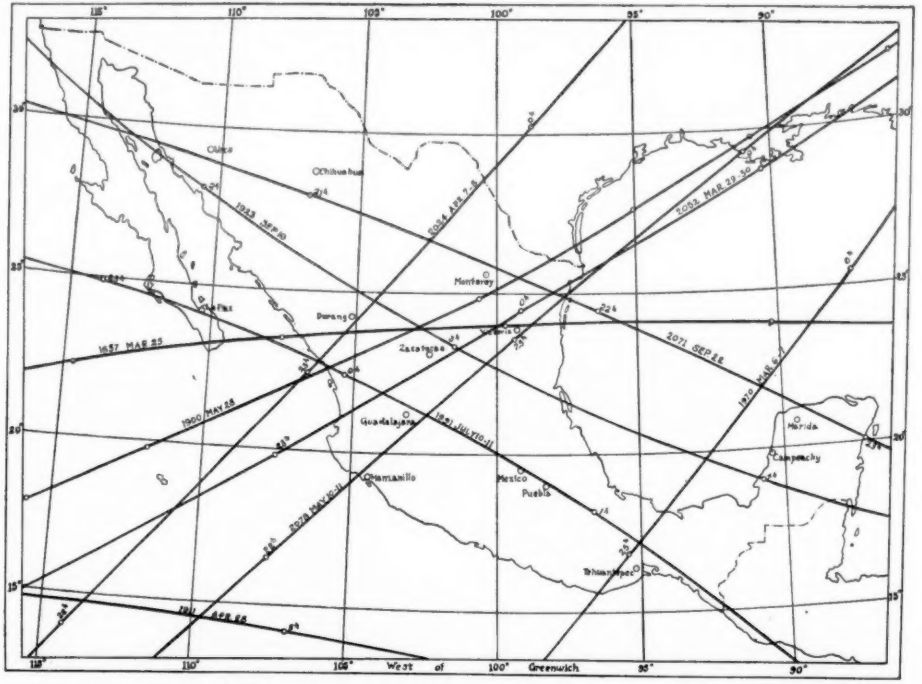
As a young boy, an eclipse of the sun in 1869 forms my earliest astronomical recollection. It was not total at my home; but nine years later our Government placed me in charge of my first eclipse expedition, which brought me almost to the Mexican border. Since then the lunar shadow has lured me twice to Japan, once to the Dutch East Indies, and thrice to Africa.

Highly significant are these experiences of the field astronomer in foreign lands; but they scarcely surpass the intense interest of the astronomer who, in the quiet of his home Observatory, calculates with unerring precision the eclipses of the future. After days and nights of close toil with the tools of the mathematician, he announces confidently, "If you journey to a remote city, perhaps on the opposite side of the globe, there, on such a day, possibly in a coming century, at such an hour, minute and second, night will come on at midday, and the ineffable corona will once again be hung in the sky."

Many years ago I undertook a general investigation of the total eclipses of the sun visible in all the countries of the globe. Very opportunely this research has already advanced to such a stage of completeness that I am now able to chart the totality-paths of all the eclipses visible in Mexico for a period of three hundred years.

Such a carefully constructed chart I have the honor of transmitting to the distinguished Congress, through the courtesy of may friend Mr. William Beer of New Orleans. It shows exactly where the central lines of all these important celestial phenomena impinge on Mexican territory. Of course the total eclipse is visible everywhere within a belt averaging about 100 miles in breadth, located on either side of these several lines.

First as to the method of this research. It was necessary at the outset to determine what mathematical tables were best adapted to the treatment of the general problem in hand. After repeated trials, the conclusion reached was that the *Canon der Finsternisse* of the late



TOTALITY-PATHS OF ECLIPSES OF THE SUN VISIBLE IN MEXICO DURING THE 300 YEARS, 1850-2150.

Baron Theodore V. Oppolzer (1841-1886) afforded the most facile means of deriving the data desired. The method, then, was to make an original calculation from Oppolzer's great work, of the precise spot on the earth where the total eclipse would fall visible, for each successive hour of local apparent time. This degree of frequency was found ample for securing that precision of curvature of the eclipse-paths, which alone made the investigation worth undertaking. In this research I have been fortunate in the assistance of my former pupil, Mr. Robert H. Baker, later Professor in Brown University, and now Director of the Columbia (Mo.) Observatory.

The period of 300 years extends from 1850 to 2150; and all the total eclipses of the sun that can happen in this interval of three complete centuries were made the subject of investigation. The comprehensive table of bare results exhibits, first of all, the date and time of day when the eclipse happens, second the latitude and longitude of the selected points of visibility on its central line, and lastly the interval of time during which the sun will be totally hidden by the moon by each of the places in question.

Here follows the table of collected results:—

Date	Local Apparent Time.			Latitude		Longitude			Duration
	d	h	m	°	′	°	′		m
1923	Sept.	9	17	37	+47	55	154	16 E	Limit
			19		49	8	174	17 E	2.1
			20		48	45	172	41 W	2.4
			21		47	23	160	14	2.8
			22		45	6	148	44	3.2
			23		41	53	138	9	3.6
		10	0		37	51	128	29	3.8
			1		33	10	119	22	3.9
			2		28	13	110	40	3.7
			3		23	22	101	25	3.2
			4		19	8	91	5	2.7
			5		15	50	79	9	2.1
			6	5	+13	31	64	6 W	Limit
1970	March	6	17	59	− 2	3	148	43 W	Limit
			19		2	26	132	9	2.1
			20		− 0	34	120	22	2.7
			21		+ 3	24	110	33	3.3
			22		9	20	102	25	3.9
			23		16	55	95	20	4.2
		7	0		25	25	87	17	4.1
			1		33	49	80	14	3.6
			2		41	14	70	25	3.1
			3		47	6	58	47	2.6
			4		51	21	45	41	2.2
			5		54	5	31	31	1.9
			5	30	+54	36	22	37 W	Limit

Date		Local Apparent Time			Latitude		Longitude			Duration
		d	h	m	°	′	°	′		m
1991	July	10	17	39	+12	37	174	46	W	Limit
			19		19	56	156	13		4.2
			20		23	30	144	14		5.1
			21		25	30	133	22		5.8
			22		26	0	123	21		6.5
			23		24	55	114	2		7.0
		11	0		22	19	105	15		7.2
			1		18	9	96	45		7.0
			2		12	35	88	9		6.4
			3		+ 5	55	78	50		5.5
			4		— 1	19	68	8		4.6
			5		8	25	55	31		3.8
			5	39	—12	44	46	13	W	Limit
2024	April	7	18	4	— 7	59	158	31	W	Limit
			19		5	17	145	25		2.7
			20		— 0	28	133	13		3.3
			21		+ 6	7	122	59		4.0
			22		14	0	114	23		4.5
			23		22	24	106	34		4.8
		8	0		30	22	98	37		4.8
			1		37	9	89	46		4.5
			2		42	22	79	27		4.0
			3		46	1	68	2		3.5
			4		48	8	55	35		3.1
			5		48	54	42	15		2.7
			6		48	20	28	8		2.4
			6	33	+47	13	20	3	W	Limit
2052	March	29	17	59	+ 1	43	161	41	W	Limit
			19		3	29	147	47		2.3
			20		6	24	135	37		2.8
			21		10	17	125	8		3.5
			22		14	51	115	56		4.1
			23		19	44	107	30		4.4
		30	0		24	28	99	10		4.4
			1		28	46	90	22		4.2
			2		32	19	80	44		3.7
			3		34	56	70	2		3.2
			4		36	35	58	13		2.7
			5		37	13	45	14		2.2
			6	13	+36	24	28	1	W	Limit
2071	Sept.	22	18	1	+32	42	145	19	W	Limit
			19		32	15	131	13		1.4
			20		30	37	118	13		1.8
			21		28	0	106	37		2.3
			22		24	27	96	20		2.8
			23		20	11	87	16		3.2
		23	0		15	27	79	4		3.5
			1		10	37	71	11		3.4
			2		6	7	62	57		3.1
			3		+ 2	17	53	48		2.5
			4		— 0	35	43	15		2.0
			5		2	20	31	1		1.5
			6	0	— 2	54	16	59	W	Limit

Date	Local Apparent Time			Latitcde		Longitude		Duration
		d	h	m	°	′	°	′	m
2078	May	10	18	13	— 9	58	150	37 W	Limit
			19		— 5	39	139	32	3.3
			20		+ 1	7	126	50	4.0
			21		8	46	116	46	4.8
			22		16	29	107	49	5.5
			23		23	31	99	29	6.0
		11	0		29	20	91	2	6.1
			1		33	39	81	58	5.8
			2		36	26	72	8	5.4
			3		37	43	61	28	4.9
			4		37	32	49	59	4.3
			5		35	52	37	38	3.7
			6		32	43	24	15	3.2
			6	43	+29	25	14	0 W	Limit

Once having derived this series of quantities and being assured of their accuracy, it was not a tedious matter to construct the graphical chart which accompanies them. Especially gratifying it was, from an astronomical point of view, to find that all these eclipses are of exceptional magnitude. Other circumstances, too, are most favourable; as none of them happen in the winter months, the sun is in north declination thus giving a maximum altitude in Mexico. But more remarkable still, the geographical location of the Republic is at or near the middle of all these tracks, so that totality happens near midday, the most advantageous time of all. The circumstances, together with the marked freedom from cloud and the high general elevation of Mexico, afford, a combination of fortuitous conditions wholly unsurpassed.

We may pass over the eclipse of the 28th April 1911, which, although a brief section of its ocean track is shown on the map, does not actually touch Mexico at any point.

The first Mexican eclipse of the future, therefore, is due the 10th September 1923. And a very famous eclipse it is, too, if we regard its past history according to the 18-year Saros recurrences. For it was at this eclipse in 1851 that the solar corona was first photographed, and at its next return in 1869 the salient discovery of coronium was made with the spectroscope. At the return of 1923, then, the splendid array of Mexican stations will attract a throng of expectant astronomers.

No eclipse then visits the Republic till the 7th March 1970, crossing the Isthmus of Tehauntepec at eleven in the morning. I do not know who was the first astronomer to remark the interesting fact that three Saros returns, comprising an interval of 54 years and one month, is the period most likely to bring back a total eclipse to very nearly the same region of the globe. This eclipse affords an excellent illustration of the exactness of the 3-Saros period in its passage over Mexico. As I have said, its track intersects Oaxaca and Vera Cruz on the 7th March 1970; it returns to Durango and Coahuila on the 8th April 2024; and yet again

to Jalisco, Potosi and Tamaulipas on the 11th May 2078. These eclipses are successive returns of the one so fully observed by English and American parties in India in 1898. If we regard its life-history, the eclipse is in early middle-age, the duration of its totality all the while increasing, until it has reached the exceptional length of six minutes in 2078.

Following the year of this last eclipse is a long period of nearly a full century wherein no total eclipse is visible anywhere on Mexican soil. I may mention here that another eclipse of the sun of a somewhat different character happens on the morning of the 30th May 1984; its track through Mexico being practically identical with that of 2078, but which I have omitted, to save confusion on the map, because it just falls short of entire totality. This eclipse, however, will be completely annular, with an exceedingly thin ring of true sunlight all around the moon, as seen from Mexican stations.

On the 30th March 2052, is a splendid noon-tide eclipse, passing over Zacatecas and Tamaulipas, with a duration of nearly four and a half minutes; and the late forenoon eclipse of the 23rd September 2071, lasting three minutes, is also excellent, stretching across the broad expanse of Northern Mexico from Sonora to Tamaulipas.

But the climax, the culmination of all the Mexican totalities for these three centuries, indeed I might say for all centuries, takes place on the 11th July 1991. It will afford unexampled opportunity for solar research that will be highly prized by the astronomers of all nations; in fact, no eclipse in past history has ever presented in any land such an array of attractive possibilities. The longest totality of which we have authentic record in the past was 6m 20s in duration; and the longest that can ever happen has been calculated to be 7m 58s. Our computations show that the great eclipse of 1991 will be total in the city of Mexico during the unprecedented interval of 7m 10s.

But this is not all: taking place almost at midday and in the month of July, the eclipsed sun will stand practically in the zenith, that region of the heavens where, in spite of craning necks, astronomers do most delight in making their observations. This comes about quite naturally, because the lowermost, and therefore the densest, layers of the atmosphere are subject to continual quiver and tremor; so that the higher in the sky the object is, the better it can be seen. Very clearly too, if the astronomer can set up his telescope on a high mountain, his chances of fine vision are still farther enhanced.

Of course Popocatepetl and Orizaba occur at once. Cannot one or both of these lofty stations be occupied? Both are very near the middle of the broad path of shadow. Never before has any country or people experienced or possessed so stupendous a vantage-ground for viewing

the most impressive celestial spectacle of the ages. Well may there be years of critical preparation. Experimental researches with compressed air, which I conducted in the Andes of Peru some years ago at an elevation of 14,000 feet, appear to indicate that the greater heights of the Mexican peaks can be occupied continuously with perfect safety and comfort.

So jealously does the sun guard the secret of his radiant energy that we shall find the astronomers of the twentieth century's last decade in no less eager pursuit of solar knowledge than we are to-day. Still will they be exclaiming with Laplace, "Ce que nous connaissons est peu de chose, mais ce que nous ignorons est immense."

So it may well be that a great eclipse of the sun in mid-heaven, viewed from a lofty and historic mountain peak, will constitute an event worthy of the fullest recognition in the annals of science, when, in 2010, the great Republic celebrates the conclusion of the second century of her Independence.

PLANET NOTES FOR JULY AND AUGUST, 1913.

During this period the sun will move fourteen degrees southward and at the end will be about nine degrees north of the equator. It will move eastward from the constellation Gemini through Cancer into Leo. Toward the end of August it will be very near the bright star Regulus.

The phases of the moon for these months are as follows:

New Moon	July	3 at	11 P.M.	C.S.T.
First Quarter		10 "	4 P.M.	"
Full Moon		17 "	12 P.M.	"
Last Quarter		26 "	6 A.M.	"
New Moon	Aug.	2 at	7 A.M.	C.S.T.
First Moon		8 "	10 P.M.	"
Full Moon		16 "	2 P.M.	"
Last Quarter		24 "	6 P.M.	"
New Moon		31 "	3 P.M.	"

The month of August is exceptional in that it has two periods of New Moon.

Mercury at the beginning of July will be visible in the west a short distance south of the sun at sunset. It will then be moving eastward a little faster than the sun and will reach a point of greatest elongation east of the sun on July 7. Soon after this period it will move toward the sun and pass between the earth and the sun on August 3, a time of inferior conjunction. It will continue to move westward and reach a point of greatest elongation west on August 21. At this time it may not be visible to the naked eye as it will rise only about an hour before sunrise.

Venus will be a brilliant object in the morning sky at the beginning of July. It will reach a period of greatest elongation west on July 3, at which time it will rise about three hours before the sun. After this date the planet moves eastward a little more rapidly than the sun, but continues to be the morning star for several months.

On July 3 the earth will be in aphelion or point of greatest distance from the sun.

Mars will continue to move eastward but not so rapidly as the sun and consequently will rise earlier each night. By the end of August it will rise shortly after midnight. Throughout this period it will therefore be visible only in the morning. During this period Mars will be approaching the earth and will be getting brighter.

THE CONSTELLATIONS AT 9:00 P. M. JULY 1, 1913.

Jupiter will be in a favorable position for observation. At the beginning of July it will rise about sunset and by the end of August it will be approaching the meridian at sunset. It will, however, be quite far south, having the declination of the sun at the time of the winter solstice. On July 4 it will be in opposition.

Saturn will move eastward about six degrees during these two months. It will be a few hours east of Mars. It will be in the constellation Taurus near the Pleiades and the bright star Aldebaran. Being east of Mars it will not rise quite as early as Mars and hence will be visible only a few hours before sunrise.

Uranus will have a slow retrograde motion during this period. On July 28 it will be in opposition, and will then rise at sunset. It will be found in the constellation Capricornus.

Neptune will be in conjunction with the sun on July 18, and will not be visible before the end of August, when it may be seen in the morning sky.

Phenomena of Jupiter's Satellites.

CENTRAL STANDARD TIME.

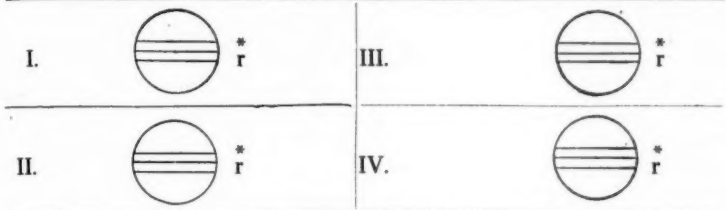
1913	h	m		1913	h	m	
July 1	13	13	II Ec. Dis.	July 28	12	39	I Oc. Dis.
2	11	12	III Ec. Dis.	29	9	47	I Tr. In.
	14	53	III Oc. Re.		10	22	I Sh. In.
3	8	19	II Sh. In.		11	16	IV Oc. Dis
	8	23	II Tr. In.		12	5	I Tr. Eg.
	11	8	II Sh. Eg.		12	40	I Sh. Eg.
	11	13	II Tr. Eg.	30	7	6	I Oc. Dis.
4	13	19	IV Sh. In.		9	58	I Ec. Re.
	13	22	IV Tr. In.	31	7	9	I Sh. Eg.
5	13	0	I Oc. Dis.	Aug. 2	11	32	II Oc. Dis.
6	10	7	I Tr. In.	4	7	58	II Sh. In.
	10	9	I Sh. In.		9	23	II Tr. Eg.
	12	25	I Tr. Eg.		10	48	II Sh. Eg.
	12	27	I Sh. Eg.	5	11	33	I Tr. In.
7	9	46	I Ec. Re.		12	17	I Sh. In.
9	14	53	III Oc. Dis.	6	8	52	I Oc. Dis.
10	10	37	II Tr. In.		11	53	I Ec. Re.
	10	54	II Sh. In.	7	6	46	I Sh. In.
	13	27	II Tr. Eg.		8	17	I Tr. Eg.
	13	44	II Sh. Eg.		9	4	I Sh. Eg.
12	7	52	II Ec. Re.		10	36	III Ec. Re.
13	7	35	III Tr. Eg.	11	8	52	II Tr. In.
	8	26	III Sh. Eg.		10	34	II Sh. In.
	11	51	I Tr. In.		11	42	II Tr. Eg.
	12	4	I Sh. In.	13	7	38	II Ec. Re.
	14	9	I Tr. Eg.		10	38	I Oc. Dis.
	14	22	I Sh. Eg.	14	7	43	III Oc. Dis.
14	9	10	I Oc. Dis.		7	47	I Tr. In.
	11	40	I Ec. Re.		8	41	I Sh. In.
15	8	35	I Tr. Eg.		10	5	I Tr. Eg.
	8	50	I Sh. Eg.		10	59	I Sh. Eg.
17	12	52	II Tr. In.		10	59	III Oc. Re.
	13	30	II Sh. In.		11	25	III Ec. Dis.
19	10	28	II Ec. Re.	15	8	16	I Ec. Re.
20	7	37	III Tr. In.		10	46	IV Ec. Dis.
	9	8	III Sh. In.	18	11	13	II Tr. In.
	10	53	III Tr. Eg.	20	10	16	II Ec. Re.
	12	26	III Sh. Eg.	21	9	35	I Tr. In.
	13	35	I Tr. In.		10	36	I Sh. In.
	13	59	I Sh. In.		11	15	III Oc. Dis.
21	7	22	IV Sh. In.		11	53	I Tr. Eg.
	10	20	IV Sh. Eg.	22	6	53	I Oc. Dis.
	10	54	I Oc. Dis.		10	11	I Ec. Re.
	13	35	I Ec. Re.	23	6	20	I Tr. Eg.
22	8	2	I Tr. In.		7	22	I Sh. Eg.
	8	27	I Sh. In.		9	35	IV Tr. In.
	10	20	I Tr. Eg.	25	8	31	III Sh. Eg.
	10	45	I Sh. Eg.	27	7	50	II Oc. Dis.
23	8	3	I Ec. Re.	28	11	25	I Tr. In.
26	9	14	II Oc. Dis.	29	7	53	II Sh. Eg.
	13	5	II Ec. Re.		8	43	I Oc. Dis.
27	10	57	III Tr. In.	30	7	0	I Sh. In.
	13	8	III Sh. In.		8	10	I Tr. Eg.
28	7	5	II Tr. Eg.		9	19	I Sh. Eg.
	8	13	II Sh. Eg.	31	8	35	I Ec. Re.

Note:—In., denotes ingress; Eg., egress; Dis., disappearance; Re., reappearance; Ec., eclipse; Oc., occultation; Tr., transit of the satellite; Sh.. transit of the shadow.

Satellites of Jupiter, July 1913.

WASHINGTON MEAN TIME.

Phases of the Eclipses of the Satellites for an Inverting Telescope.



Configurations at 11h 30m for an Inverting Telescope.

Day	West	East
1	·3 1· ·2 ○	4·
2	·3 ○ ·1 ·2 4·	
3	○2· ·1 ○ 3 4·	
4	·2 ○ 4· 1· 3·	
5	4· ·1 ○ ·2 3·	
6	○1· 4· 3· ○ 2·	
7	4· 3· 2· ○ ·1	
8	4· ·3 2 1· ○	
9	·4 ·3 ○ ·1 ·2	
10	○2· ·4 1· ○ ·3	
11	·4 ·2 ○ ·1 ·3	
12	4 1 ○ ·2 · ·3	
13	3· ○ 1· ·4 2·	
14	3· 2· ○ 4· ·1●	
15	3· ·2 1· ○ 4·	
16	·3 ○ ·1 ·2 ·4	
17	1· ○2· ·3 4·	
18	2· ○ 1· ·3 4·	
19	·1 ○·2 ·3 4·	
20	○3· ○ 1· 2· 4.	
21	3· 2· 1 4· ○	
22	·3 4· ·2 1·○	
23	4· ·3 ○ ·1 ·2	
24	4· 1· ○ 2· ·3	
25	·4 2· ○ ·1 ·3	
26	·4 ·1 ○ ·3 ·2●	
27	·4 ○ 1· 2· 3·	
28	4 3· 2· ·1 ○	
29	○1· ·3 ·2 4 ○	
30	3· ○ ·1 ·2 ·4	
31	1· ○ 3 2 ·4	

Occultations Visible at Washington.

Date 1913	Star's Name	Magnitude	IMMERSION. Washington M.T.	Angle f'm N.	EMERSION. Washington M.T.	Angle f'm N	Duration
			h m	°	h m	°	h m
July 13	π Scorpii	3.0	9 1	105	10 26	289	1 25
17	ω Sagittarii	4.8	12 14	114	13 13	200	0 59
21	*h* Aquarii	5.4	12 5	9	13 0	282	0 55
27	16 Tauri	5.4	16 34	16	17 26	288	0 52
27	17 Tauri	3.8	16 13	58	17 28	247	1 15
29	107 B Aurigae	6.5	13 20	105	14 4	234	0 44
Aug. 8	17 G Librae	6.4	7 57	120	9 11	284	1 14
8	18 G Librae	6.1	8 39	131	9 46	268	1 7
18	337 B Aquarii	6.4	8 0	42	9 1	261	1 1
18	342 B Aquarii	6.5	9 44	2	10 26	291	0 42
21	π Piscium	5.6	8 27	68	9 21	236	0 54
27	134 B Gemin.	6.5	13 33	91	14 25	270	0 52

VARIABLE STARS.

Approximate Magnitudes of Variable Stars on May 1, 1913.

[Communicated by the Director of Harvard College Observatory, Cambridge, Mass.

Name.	R. A. 1900. h m	Decl. 1900. ° ′	Magn.	Name.	R.A. 1900. h m	Decl. 1900. ° ′	Magn.
X Androm.	0 10.8	+46 27	11.6*i*	V Monoc.	6 17.7	− 2 9	7.5
T Cassiop.	17.8	+55 14	12.1	U Lyncis	31.8	+59 57	11.8*d*
Y Cephei	31.3	+79 48	10.5*d*	S Lyncis	35.9	+58 0	12.7 *i*
U Cassiop.	40.8	+47 43	<12.	X Gemin.	40.7	+30 23	12.7
W Cassiop.	49.0	+58 1	10.3	Nova Gem. No.2	45.5	+32 17	8.8
– Androm.	1 10.4	+41 12	<13.	Y Monoc.	51.3	+11 22	10.4 *i*
S Cassiop.	12.3	+72 5	10.5	X Monoc.	52.4	− 8 56	7.6
RZ Persei	23.6	+50 20	10.4 *i*	R Lyncis	53.0	+55 28	10.0*d*
RU Androm.	32.8	+38 10	11.0*d*	V Can.Min.	7 1.5	+ 9 2	<14.
Y Androm.	33.7	+38 50	9.4 *i*	R Gemin.	1.3	+22 52	12.8
X Cassiop.	49.8	+58 46	12.3	S Can.Min.	27.3	+ 8 32	8.1*d*
W Androm.	2 11.2	+43 50	12.3	S Gemin.	37.0	+23 41	11.1*d*
Z Cephei	12.8	+81 13	13.7	R Cancri	8 11.0	+12 2	8.6
S Persei	15.7	+58 8	8.1	V Cancri	16.0	+17 36	9.6
RR Persei	21.7	+50 49	13.5	U Cancri	30.0	+19 14	9.9
RR Cephei	29.4	+80 42	13.2	S Hydrae	48.4	+ 3 27	10.6*d*
W Persei	43.2	+56 34	9.9	T Cancri	51.0	+20 14	8.8
W Tauri	4 22.2	+15 49	9.4	Y Draconis	9 31.1	+78 18	13.5
T Camelop.	30.4	+65 57	8.5	R Leo.Min.	39.6	+34 58	10.2*d*
X Camelop.	32.6	+74 56	12.8	R Leonis	42.2	+11 54	7.0*d*
R Aurigae	5 9.2	+53 28	12.8	Y Hydrae	46.4	−22 33	6.5
S Aurigae	20.5	+34 4	8.8	U Hydrae	10 32.6	−12 52	4.6
W Aurigae	20.1	+36 49	9.2	R Urs.Maj.	37.6	+69 18	12.3
S Camelop.	30.2	+68 45	9.2	V Hydrae	46.8	−20 43	6.4
U Aurigae	35.6	+31 59	8.8	S Leonis	11 5.7	+ 6 0	10.6 *i*
SU Tauri	43.2	+19 2	9.8	R Com. Beren.	59.1	+19 20	<13.
Z Tauri	46.7	+15 46	<12.	SS Virginis	12 20.1	+ 1 19	7.3
U Orionis	49.9	+20 10	7.0	T Can. Ven.	25.2	+32 3	9.4
V Camelop.	49.4	+74 30	11.0*d*	Y Virginis	28.7	− 3 52	<12.
Z Aurigae	53.6	+53 18	10.9	T Urs.Maj.	31.8	+60 2	12.6
W Camelop.	6 12.2	+75 30	13.8	R Virginis	33.4	+ 7 32	7.4

Approximate Magnitudes of Variable Stars on May 1, 1913, Continued.

Name.	R. A. 1900. h m	Decl. 1900. ° ′	Magn.	Name.	R.A. 1900 h m	Decl. 1900 ° ′	Magn.
RS Urs. Maj.	12 34.4	+59 2	12.8	W Lyrae	18 11.5	+36 38	9.8
S Urs. Maj.	39.6	+61 38	12.0	SV Draconis	31.2	+49 18	9.4
RU Virginis	42.2	+ 4 42	9.5	RY Lyrae	41.2	+34 34	10.0
U Virginis	46.0	+ 6 6	10.1	Z Lyrae	56.0	+34 49	10.9*d*
RR Urs. Maj.	13 22.5	+62 55	9.8	V Lyrae	19 5.2	+29 30	10.9*d*
R Hydrae	24.2	—22 46	6.2*d*	S Lyrae	9.1	+25 50	<14.
T Urs. Min.	32.6	+73 56	12.3	U Draconis	9.9	+67 7	11.8
R Can. Ven.	44.6	+40 2	8.0	TZ Cygni	13.4	+50 0	11.3
U Urs. Min.	14 15.1	+67 15	8.9	U Lyrae	16.6	+37 42	11.0
S Bootis	19.5	+54 16	10.9	R Cygni	34.1	+49 58	9.8
RS Virginis	22.3	+ 5 8	13.2	RT Cygni	40.8	+48 32	8.6*d*
V Bootis	25.7	+39 18	11.1	TU Cygni	43.3	+48 49	12.4
R Camelop.	25.1	+84 17	8.2	R Delphini	20 10.1	+ 8 47	11.4
R Bootis	32.8	+27 10	9.6	V Sagittae	15.8	+20 47	11.9
S Cor. Bor.	15 17.3	+31 44	9.0	U Cygni	16.5	+47 35	8.3
RU Librae	27.7	−14 59	<13.	ST Cygni	29.9	+54 38	12.8
X Cor. Bor.	45.2	+36 35	10.2	V Cygni	38.1	+47 47	10.5
R Serpentis	46.1	+15 26	7.2	T Aquarii	44.7	— 5 31	<11.
V Cor. Bor.	46.0	+39 52	8.8	RZ Cygni	48.5	+46 59	12.0
RZ Scorpii	58.6	—23 50	7.8	TW Cygni	21 1.8	+29 0	12.3
W Cor. Bor.	16 11.8	+38 3	8.5	X Cephei	3.6	+82 40	13.4
U Herculis	21.4	+19 7	9.2	R Equulei	8.4	+12 23	<13.
W Herculis	31.7	+37 32	9.0*d*	T Cephei	8.2	+68 5	9.0 *i*
R Urs. Min.	31.3	+72 28	9.9	W Cygni	32.2	+44 56	5.9
R Draconis	32.4	+66 58	12.4	Y Pegasi	22 6.8	+13 52	11.1
S Herculis	47.4	+15 7	11.6	RS Pegasi	7.4	+14 4	13.6
RV Herculis	56.8	+31 22	11.8	V Cassiop.	23 7.4	+59 8	7.8
R Ophiuchi	17 2.0	—15 58	11.2	Z Cassiop.	39.7	+56 2	<13.
V Draconis	56.3	+54 53	13.4	R Cassiop.	53.3	+50 50	12.0 *i*
T Herculis	18 5.3	+31 0	8.7	Y Cassiop.	58.2	+55 7	13.0
W Draconis	5.4	+65 56	11.2*d*	SV Androm.	59.2	+39 33	<13.
X Draconis	6.8	+66 8	13.7				

The letter *i* denotes that the light is increasing; the letter *d*, that the light is decreasing; the sign < that the variable is fainter than the appended magnitude.

The above magnitudes have been compiled at the Harvard College Observatory from observations made by the following observers:—H. C. Bancroft, Jr., T. C. H. Bouton, A. B. Burbeck, A. P. C. Craig, C. E. Furness, E. Gray, F. E. Hathorn, S. C. Hunter, M. W. Jacobs, Jr., J. B. Lacchini, F. C. Leonard, C. Y. McAteer, W. T. Olcott, E. W. Raymond, F. E. Seagrave, H. M. Swartz, D. Todd, H. W. Vrooman, I. E. Woods, and A. S. Young.

Minima of Variable Stars of Short Period.

[Calculated by Myrtle L. Richmond, E. R. Peterson and S. N. Stearns at Goodsell Observatory.]

Given to the nearest hour in Greenwich mean time; to obtain eastern Standard time subtract 5^h; Central Standard 6^h, etc.

Star	R. A. 1900	Decl. 1900	Magnitude	Approx. Period	Greenwich mean times of minima in 1913 July				August			
	h m	° ′		d h	d h	d h	d h	d h	d h	d h	d h	d h
SY Androm.	0 08.0	+43 09	9.5—13.0	34 21.9	11 21				15 19			
RT Sculptor	0 31.5	−26 13	9.6—10.5	0 12.3	10 16;	26 0;			10 9;	25 17		
UU Androm.	38.5	+30 24	10.7—11.9	1 11.7	11 22;	26 19;			10 16;	25 13		
U Cephei	0 53.4	+81 20	7.0— 9.0	2 11.8	9 8;	24 7;			15 18;	30 17		
Z Persei	2 33.7	+41 46	9.4—12	3 01.4	9 16;	21 21;			9 5;	21 10		
RY Persei	39.0	+47 43	8.0—10.3	6 20.7	11 1;	24 19;			14 9;	28 3		

Minima of Variable Stars of Short Period—Continued.

Star	R. A. 1900	Decl. 1900	Magnitude	Approx. Period	Greenwich mean times of minima in 1913							
					July				August			
	h m	° ′		d h	d h	d h	d h	d h	d h	d h	d h	d h
RZ Cassiop.	2 39.9	+69 13	6.4— 7.8	1 04.7	14 11;	28 20;	12 4;	26 12				
ST Persei	53.7	+38 47	8.5—10.5	2 15.6	8 11;	24 8;	9 5;	25 3				
RX Cassiop.	2 58.8	+67 11	8.6— 9.1	32 07.6	18 3		19 11					
Algol	3 01.7	+40 34	2.3— 3.5	2 20.8	10 1;	21 12;	7 17;	24 22				
RT Persei	16.7	+46 12	9.5—11.5	0 20.4	13 7;	26 21;	9 11;	23 1				
λ Tauri	55.1	+12 12	3.4— 4.5	3 22.9	8 5;	24 0;	8 20;	24 15				
RW Tauri	3 57.8	+27 51	7.1—<11	2 18.5	10 0;	26 14;	12 5;	28 20				
RV Persei	4 04.2	+33 59	9.5—11.0	1 23.4	10 16;	22 12;	9 7;	21 3				
RW Persei	4 13.3	+42 04	8.8—11.0	13 04.8	16 7;	29 12;	11 17;	24 22				
SZ Tauri	31.4	+18 20	7.2— 7.7	3 03.6	9 8;	21 22;	9 20;	22 10				
RS Cephei	4 48.6	+80 06	9.5—12.0	12 10.1	10 20;	23 6;	17 2;	29 12				
TT Aurigae	5 02.8	+39 27	7.8— 8.7	0 16.0	9 20;	23 4;	12 4;	25 12				
RY Aurigae	11.5	+38 13	10.7—11.7	2 17.5	11 12;	22 10;	7 19;	18 17				
RZ Aurigae	42.9	+31 40	10.6—13.3	3 00.3	12 4;	24 5;	11 7;	23 8				
SV Tauri	45.8	+28 05	9.4—11.0	2 04.0	8 12;	21 12;	10 0;	23 0				
SV Gemin.	5 54.6	+24 28	9.8—<11	4 00.2	11 17;	27 18;	12 19;	28 19				
RW Gemin.	5 55.4	+23 08	9.5—11.0	2 20.8	7 2;	18 13;	10 11;	21 22				
U Columbae	6 11.2	−33 03	9.4—10.2	2 19.2	8 10;	19 15;	11 0;	22 5				
SX Gemin.	22.0	+20 37	10.8—11.5	1 08.8	11 19;	22 17;	8 3;	19 1				
RW Monoc.	6 49.4	− 7 28	9.8—10.5	0 21.5	11 7;	26 13;	10 19;	26 1				
RX Gemin.	43.6	+33 21	8.8— 9.6	12 05.0	10 23;	23 4;	16 14;	28 19				
RU Monoc.	29.3	+ 8 54	9.0—10.8	1 21.7	10 18;	25 3;	8 11;	22 19				
R Can. Maj.	7 14.9	−16 12	5.8— 6.4	1 03.3	7 10;	24 11;	10 11;	21 20				
RY Gemin.	21.7	+15 52	8.9—<10	9 07.2	19 10;	28 17;	16 8;	25 15				
Y Camelop.	27.6	+76 17	9.5—12	3 07.3	13 7;	26 13;	8 18;	21 23				
RR Puppis	43.5	−41 08	9.5—	6 10.3	11 5;	24 2;	12 9;	25 5				
V Puppis	7 55.4	−48 58	4.1— 5.8	1 10.9	10 4;	24 17;	15 12;	30 1				
X Carinae	8 29.1	−58 53	7.9— 8.7	0 13.0	8 22;	25 4;	10 10;	21 6				
S Cancri	38.2	+19 24	8.2—10	9 11.6	11 8;	30 7;	18 6;	27 18				
S Antliae	27.9	−28 11	6.7— 7.8	0 07.8	11 22;	24 21;	13 8;	26 7				
S Velorum	28.5	−44 46	7.8— 9.1	5 22.4	8 21;	20 18;	7 13;	25 9				
Y Leonis	9 31.1	+26 41	9.3—11.2	1 16.5	10 21;	27 18;	13 14;	30 11				
RR Velorum	10 17.8	−41 36	10.0—10.9	1 20.5	14 9;	23 15;	11 4;	29 17				
SS Carinae	10 54.2	−61 23	12.2—12.8	3 07.0	7 15;	20 19;	9 15;	22 20				
ST Urs. Maj.	11 22.4	+45 44	6.7— 7.2	8 19.2	13 14;	31 5;	17 19;	26 14				
RW Urs. Maj.	35.4	−51 34	9.3—10.3	7 07.9	13 0;	27 16;	11 8;	26 0				
Z Draconis	11 40.6	+72 48	9.5—12.5	1 08.6	8 20;	22 9;	11 18;	25 7				
SS Centauri	13 07.2	−63 37	8.8—10.4	2 11.5	13 7;	28 4;	12 1;	26 22				
δ Librae	14 55·6	− 8 07	5. — 6.7	2 07.9	12 19;	26 18;	9 17;	23 16				
U Coronae	15 14.1	+32 01	7.6— 8.7	3 10.9	9 22;	23 8;	13 1;	26 21				
TW Draconis	32.4	+64 14	7.0— 8.9	2 19.4	9 22;	26 18;	12 14;	29 10				
114.1908 Librae	15 43.4	−64 14	9.3—11.5	0 18.4	11 17;	27 0;	11 8;	26 15				
SW Ophiuchi	16 11.1	− 6 44	9.2—10.0	2 10.7	12 13;	27 5;	10 21;	25 13				
SX Ophiuchi	12.6	− 6 25	10.5—11.2	2 01.5	14 8;	30 20;	16 8;	24 14				
R Arae	31.1	−56 48	6.7— 8.	4 10.2	14 17;	23 14;	10 6;	19 3				
TT Herculis	16 49.9	+17 00	8.9— 9.3	20 18.1	20 21;	30 14;	20 8;	31 10				
TU Herculis	17 09.8	+30 50	9.5—12	2 06.4	9 5;	22 19;	12 5;	25 19				
U Ophiuchi	11.5	+ 1 19	6.0— 6.7	0 20.1	16 17;	25 3;	10 21;	27 16				
u Herculis	13.6	+33 12	5.1— 5.6	2 01.2	12 15;	24 22;	12 9;	24 16				
TX Herculis	15.4	+42 00	8.3— 9.0	1 00.7	13 7;	27 17;	11 3;	25 13				
RV Ophiuchi	29.8	+ 7 19	9. —<11	3 16.5	11 2;	25 20;	9 14;	24 8				
SZ Herculis	36.0	+33 01	9.5—10.3	0 19.6	10 15;	26 23;	12 8;	28 17				
TX Scorpii	48.6	−34 13	7.5— 8.2	0 22.6	15 10;	30 11;	14 13;	29 15				
Z Herculis	53.6	+15 09	7.1— 7.9	3 23.8	16 21;	24 21;	9 20;	25 19				
WX Sagittae	53.6	−17 24	9.2—10.8	2 36.6	13 12;	26 7;	8 2;	20 20				
WY Sagittae	17 54.9	−23 1	9.5—10.6	4 16.0	8 13;	22 13;	10 5;	19 13				
SX Draconis	18 03.0	+58 23	9.3—10.5	5 04.1	11 5;	26 17;	11 5;	26 17				
RS Sagittarii	11.0	−34 08	5.9— 6.3	2 10.0	9 9;	23 21;	14 15;	29 2				
V Serpentis	18 11.1	−15 34	9.5—11.1	3 10.9	13 12;	27 8;	10 3;	23 22				

Minima of Variable Stars of Short Period.—Continued.

Star	R. A. 1900	Decl. 1900	Magnitude	Approx. Period	Greenwich mean time of minima in 1913							
					July				August			
	h m	° ′		d h	d h	d h	d h	d h	d h	d h	d h	d h
RZ Scuti	18 21.1	− 9 15	7.4— 8.3	15 3.2	8 4;	23 8;	7 11;	22 14				
RZ Draconis	21.8	+58 50	9.5—10.2	0 13.2	11 12;	22 12;	8 1;	24 14				
RX Herculis	26.0	+12 32	7.0— 7.6	0 21.3	15 12;	24 10;	11 5;	28 23				
SX Sagittarii	39.7	−30 36	8.6— 9.4	2 01.8	9 20;	22 7;	10 0;	22 11				
RR Draconis	18 40.8	+62 34	8.5—<12	2 19.9	16 8;	24 20;	10 20;	27 19				
RS Scuti	43.7	−10 21	9.3—10.3	0 15.9	12 16;	25 23;	8 6;	21 13				
β Lyrae	46.4	+33 15	3.4— 4.5	12 21.8	17 6;	30 4;	12 2;	25 0				
U Scuti	18 48.9	−12 44	9.0— 9.8	0 22.9	19 3;	28 16;	16 18;	26 2				
RX Draconis	19 01.1	+58 35	9.3—10.2	1 21.5	8 21;	24 0;	15 17;	30 21				
RV Lyrae	12.5	+32 15	11. —13	3 14.4	13 14;	27 23;	11 10;	25 19				
RS Vulpec.	13.4	+22 16	6.9— 8.0	4 11.4	12 15;	30 13;	17 11;	26 10				
U Sagittae	14.4	+19 26	6.7— 9.0	3 09.1	14 9;	27 21;	10 10;	23 22				
Z Vulpec.	17.5	+25 23	7.3— 8.5	2 10.9	10 13;	25 7;	9 1;	23 18				
TT Lyrae	24.3	+41 30	9.0—<11	5 05.8	9 13;	25 7;	10 0;	25 18				
120.1907 Draconis	19 26.2	+68 44	9.3—10	1 15.1	11 20;	24 22;	13 11;	26 12				
SY Cygni	19 42.7	+32 28	10 —12	6 00.2	11 9;	23 9;	10 9;	22 10				
WW Cygni	20 00.6	+41 18	9.5—12.5	3 07.6	11 15;	24 21;	13 19;	27 1				
SW Cygni	03.8	+46 01	9. —12	4 13.8	14 14;	23 18;	11 1;	29 8				
VW Cygni	11.4	+34 12	9.5—11.5	8 10.3	16 8;	24 18;	10 15;	27 12				
RW Capric.	12.2	−17 59	8.8—10.6	3 09.4	13 13;	27 3;	9 16;	23 6				
UW Cygni	19.6	+42 55	10.5—13	3 10.8	13 18;	27 13;	10 8;	24 4				
V Vulpec.	32.3	+26 15	8.0—9.0	37 19.0	14 16		21 11					
W Delphini	33.1	+17 56	9.5—11.5	4 19.4	12 21;	22 12;	10 17;	29 23				
RR Delphini	38.9	+13 35	10.5—11.8	4 14.4	18 22;	28 3;	15 13;	24 17				
Y Cygni	48.1	+34 17	7.1— 7.9	1 12.0	9 13;	24 13;	8 12;	23 12				
WZ Cygni	49.3	+38 27	9.8—10.8	0 14.0	8 2;	25 15;	12 4;	23 20				
RR Vulpec.	20 50.5	+27 32	9.6—11.0	5 01.2	11 0;	25 4;	9 7;	24 11				
VV Cygni	21 02.3	+45 23	12.1—13.8	1 11.4	9 19;	24 14;	15 18;	30 12				
AE Cygni	09.0	+30 20	10.8—11.4	0 23.3	19 21;	29 13;	17 23;	27 15				
UZ Cygni	55.2	+43 52	9. —11.5	31 07.3	20 19		21 1					
RT Lacertae	21 57.4	+43 24	9.1—10.5	5 01.7	10 15;	25 20;	10 1;	25 6				
RW Lacertae	22 40.6	+49 08	10.2—11.2	5 04.4	9 19;	25 8;	9 21;	25 11				
X Lacertae	22 45.0	+55 54	8.2— 8.6	5 10.6	10 20;	21 17;	7 1;	23 9				
TT Androm.	23 08.7	+45 36	10.5—11.3	2 18.3	11 13;	28 3;	13 17;	30 7				
Y Piscium	29.3	+ 7 22	9.0—12.0	3 18.4	14 10;	29 12;	13 14;	28 15				
TW Androm.	23 58.2	+32 17	8.6—11.5	4 02.9	15 19;	24 1;	9 13;	26 0				

Maxima of Variable Stars of Short Period.

[Calculated by May E. Abbott, Hazel H. Barnard, Helen A. Orr, and Myrtle L. Richmond at Goodsell Observatory.]

Given to the nearest hour in Greenwich mean time. To obtain Eastern standard time subtract 5^h; Central standard time 6^h etc.

Star	R. A. 1900	Decl. 1900	Magnitude	Approx. Period	Greenwich mean times of maxima in 1913							
					July				August			
	h m	° ′		d h	d h	d h	d h	d h	d h	d h	d h	d h
SX Cassiop.	0 05.5	+54 20	8.6— 9.4	36 13.7	10 16		16 6					
SY Cassiop.	0 09.8	+57 52	9.3— 9.9	4 1.7	13 21;	30 4;	15 11;	31 17				
RR Ceti	1 27.0	+ 0 50	8.3— 9.0	0 13.3	13 10;	28 21;	13 9;	28 21				
RW Cassiop.	1 30.7	+57 15	8.9—11.0	14 19.2	14 7;	29 2;	12 22;	27 17				
V Arietis	2 09.6	+11 46	8.3— 9.0	0 23.8	15 6;	23 5;	8 2;	23 23				
SU Cassiop.	2 43.0	+68 28	6.5— 7.0	1 22.8	16 5;	31 20;	16 10;	31 23				
TU Persei	3 01.8	+52 49	11.4—12.2	0 14.6	3 12;	28 2;	11 15;	26 5				
RW Camelop.	3 46.2	+58 21	8.2— 9.4	16 00.0	4 0;	20 0;	5 0;	21 0				

Maxima of Variable Stars of Short Period.—Continued.

Star	R.A. 1900	Decl. 1900	Magnitude	Approx. Period	Greenwich mean times of maxima in 1913							
					July				August			
	h m	° ′		d h	d	h	d	h	d	h	d	h
SX Persei	4 10.2	+41 27	10.4—11.2	4 06.9	15	20;	24	10;	10	14;	27	18
SV Persei	42.8	+42 07	8.8— 9.6	11 03.1	18	9;	29	12;	20	18;	31	21
RX Aurigae	4 54.5	+39 49	7.2— 8.1	11 15.0	17	11;	29	2;	9	17;	21	9
SX Aurigae	5 04.6	+42 02	8.0— 8.7	1 12.8	10	9;	25	17;	9	23;	25	8
SY Aurigae	05.5	+42 42	8.4— 9.5	10 03.3	13	4;	23	7;	12	14;	22	17
Y Aurigae	21.6	+42 21	8.6— 9.6	3 20.6	9	20;	25	6;	9	17;	25	3
RZ Gemin.	5 56.6	+22 15	9.1—10.0	5 12.7	11	13;	22	14;	8	4;	24	18
RS Orionis	6 16.5	+14 43	7.8— 8.5	7 13.4	10	5;	25	8;	9	11;	24	13
T Monoc.	19.8	+ 7 08	5.7— 6.8	27 00.3	2	7;	29	7;	26	8		
RZ Camelop.	23.7	+67 06	11.0—13.0	0 11.5	8	17;	23	3;	13	18;	28	4
W Gemin.	29.2	+15 24	6.8— 7.6	7 22.0	14	7;	30	3;	14	23;	30	19
ζ Gemin.	6 58.2	+20 43	3.7— 4.5	10 03.7	12	19;	22	23;	12	6;	22	10
RU Camelop.	7 10.9	+69 51	8.5— 9.8	22 06.5	9	8;	31	15;	22	21		
RR Gemin.	7 15.2	+31 04	10.0—11.5	0 09.5	12	20;	28	17;	13	14;	29	12
V Carinae	8 26.7	−59 47	7.2— 8.0	6 16.7	11	2;	24	11;	7	20;	21	6
T Velorum	8 34.4	−47 01	7.5— 8.5	4 15.3	19	4;	28	11;	16	0;	25	7
W Carinae	9 19.2	−55 32	7.5— 8.5	4 08.9	16	3;	24	21;	11	8;	28	20
W Ursae Maj.	9 36.7	+56 24	7.9— 8.6	0 04.0	10	9;	23	17;	12	18;	26	2
RR Leonis	10 02.1	+24 03	9.1—10.1	0 10.9	12	12;	26	2;	8	15;	22	5
SW Draconis	11 32.2	+67 53	8.9— 9.6	0 16.0	9	0;	22	5;	11	0;	24	5
S Muscae	12 07.4	−69 36	6.5— 7.3	9 15.8	14	22;	24	14;	12	21;	22	13
SU Draconis	12.8	+70 04	8.8— 9.6	0 13.7	11	20;	27	19;	12	17;	28	16
T Crucis	15.9	−61 44	6.8— 7.6	6 17.6	14	1;	27	12;	9	23;	23	10
R Crucis	18.1	−61 04	6.8— 8.0	5 19.8	12	1;	23	16;	10	4;	21	19
S Crucis	48.4	−57 53	6.6— 7.8	4 16.6	7	0;	25	18;	8	20;	22	21
RZ Centauri	12 55.6	−64 05	8.5— 8.9	1 21.0	12	7;	27	7;	11	7;	26	7
W Virginis	13 20.9	− 2 52	8·7—10.4	17 06.5	13	2;	30	9;	16	15		
RV Ursae Maj.	13 29.4	+54 31	9.2— 9.9	0 11.2	11	16;	25	17;	8	18;	22	19
ST Virginis	14 22.5	− 0 27	10.3—11.4	0 09.9	8	16;	25	2;	10	12;	26	22
V Centauri	25.4	−56 27	6.4— 7.8	5 11.9	11	2;	22	2;	6	13;	23	1
RS Bootis	29.3	+32 11	8.9—10.0	0 09.1	14	24;	30	2;	14	4;	29	6
RU Bootis	14 41.5	+23 44	12.8—14.3	0 11.9	14	13;	29	9;	13	5;	28	1
R Triang. Austr.	15 10.8	−66 08	6.7— 7.4	3 09.3	14	8;	27	21;	10	10;	24	0
S Triang. Austr.	15 52.2	−63 29	6.4— 7.4	6 07.8	12	18;	25	10;	13	9;	26	0
S Normae	16 10.6	−57 39	6.5— 7.4	9 18.1	15	5;	24	23;	13	11;	23	5
RW Draconis	33.7	+58 03	9.6—10.8	0 10.6	18	11;	27	8;	14	1;	31	18
RV Scorpii	16 51.8	−33 27	6.7— 7.4	6 01.5	11	16;	23	19;	11	0;	23	3
X Sagittarii	17 41.3	−27 48	4.4— 5.0	7 00.3	14	6;	28	7;	11	7;	25	8
Y Ophiuchi	47.3	− 6 07	6.1— 6.5	17 02.9	10	16;	27	19;	13	22;	31	1
W Sagittarii	17 58.6	−29 35	4.3— 5.1	7 14.3	11	2;	26	7;	10	11;	25	16
Y Sagittarii	18 15.5	−18 54	5.4— 6.2	5 18.6	12	0;	23	13;	9	21;	21	10
U Sagittarii	18 26.0	−19 12	6.5— 7.3	6 17.9	10	22;	24	10;	13	15;	27	3
Y Scuti	32.6	− 8 27	8.7— 9.2	10 08.3	20	18;	31	2;	20	19;	31	3
Y Lyrae	34.2	+43 52	11.3—12.3	0 12.1	9	18;	21	19;	8	22;	20	23
RZ Lyrae	39.9	+32 42	9.9—11.2	0 12.3	10	12;	22	19;	10	5;	22	11
RT Scuti	44.1	−10 30	9.1— 9.7	0 11.9	10	11;	22	9;	9	5;	21	2
κ Pavonis	18 46.6	−67 22	3.8— 5.2	9 02.2	17	3;	26	5;	13	9;	31	14
U Aquilae	19 24.0	− 7 15	6.2— 6.9	7 00.6	12	15;	26	16;	9	17;	23	18
XZ Cygni	30.4	+56 10	8.7— 9.3	0 11.2	9	12;	23	12;	13	12;	27	12
U Vulpec.	32.2	+20 07	6.9— 7.6	7 23.5	12	20;	28	20;	13	19;	29	18
SU Cygni	40.8	+29 01	6.6— 7.4	3 20.3	14	13;	29	22;	14	8;	29	17
η Aquilae	47.4	+ 0 45	3.7— 4.5	7 04.2	9	8;	23	20;	14	5;	28	13
S Sagittae	51.5	+16 22	5.6— 6.4	8 09.2	16	10;	24	19;	10	14;	27	8
X Vulpec.	19 53.3	+26 17	9.5—10.5	6 07.7	11	2;	23	18;	11	16;	24	8
XX Cygni	20 01.3	+58 40	10.5—11.5	0 03.2	8	17;	22	4;	11	10;	24	21
X Cygni	39.5	+35 14	6.0— 7.0	16 09.3	7	16;	24	1;	9	10;	25	20
T Vulpec.	20 47.2	+27 52	5.5— 6.5	4 10.5	9	4;	26	21;	9	5;	22	12

Maxima of Variable Stars of Short Period.—Continued.

Star	R.A. 1900	Decl. 1900	Magnitude	Approx. Period	Greenwich mean times of maxima in 1913.							
					July				August			
	h m	° ′		d h	d	h	d	h	d	h	d	h
WY Cygni	20 52.3	+30 03	9.5—10.3	0 13.5	8	16;	22	3;	11	8;	24	19
RV Capric.	55.9	−15 37	9.2—10.1	0 10.7	10	2;	23	13;	12	16;	26	2
TX Cygni	20 56.4	+42 12	8.5— 9.7	14 17.4	9	16;	24	10;	8	3;	22	20
VY Cygni	21 00.4	+39 34	8.9 - 9.5	7 20.6	13	15;	29	8;	14	1;	29	19
VZ Cygni	21 47.7	+42 40	8.4— 9.2	4 20.7	6	17;	26	4;	9	18;	24	7
Y Lacertae	22 05.2	+50 33	9.1— 9.6	4 07.8	11	3;	28	10;	14	17;	23	9
δ Cephei	25.5	+57 54	3.7— 4.6	5 08.8	11	18;	22	11;	7	13;	23	16
Z Lacertae	36.9	+56 18	8.2— 9.0	10 21.1	17	0;	27	21;	18	15;	29	12
RR Lacertae	37.5	+55 55	8.5— 9.2	6 10.1	12	10;	25	6;	13	12;	26	9
V Lacertae	22 44.5	+55 48	8.2— 8.9	4 23.6	6	8;	26	6;	10	5;	25	4
SW Cassiop.	23 03.7	+58 11	9.2— 9.7	5 10.6	9	0;	25	8;	10	15;	21	12
RS Cassiop.	32.6	+61 52	9.1—10.0	6 07.1	9	8;	21	22;	9	19;	22	9
RY Cassiop.	47.2	+58 11	9.2—10.0	12 03.4	16	6;	28	9;	9	13;	21	16
U Pegasi	23 52.9	+15 24	9.3— 9.9	0 04.5	9	22;	24	22;	8	22;	23	22

The Increase in the Brightness of α Orionis is corroborated in a communication from Professor M. Moye, Montpellier, France, as follows: "I may state that the rise of this star seems pretty sure to me. In March, I noticed, again and again, that α Orionis was distinctly brighter than Aldebaran, never reaching Capella, however, but rather above Rigel."

New Variable Stars are reported in *A. N.* 4640 as follows:

(1) 4.1913 Tauri, whose position for 1900 is given approximately as $\alpha = 4^h\ 29^m\ 1^s.9$, $\delta = +\ 15^\circ\ 3'.3$, was found by Mr. H. G. S. Barrett at the Radcliffe Observatory, Oxford. From a series of plates and also from a series of visual observations, this star seems to be practically constant in its light, except for a few instances in which it is fainter than normally. This suggests a star of the Algol Type. The variation is slight, the visual limits being approximately 11.0 and 11.6 magnitude.

(2) 5.1913 Arietis, in position for 1900, $\alpha = 3^h\ 2^m\ 15^s.8$, $\delta = +\ 26^\circ\ 36'.3$, also was discovered by Mr. Barrett at the Radcliffe Observatory. On a plate on which three exposures were made at intervals of six months for the purpose of parallax determination, this star appears in the first and third exposures as of about the eleventh magnitude, but is entirely invisible in the second exposures and must therefore have been fainter than the thirteenth magnitude. Visual observations were made showing it to be fainter than 13.0 magnitude. There is not enough data at hand to determine the elements of these two variables.

(3) 6.1913 Persei, together with the three following stars, is announced by C. R. D'Esterre. For this star the extreme range photographically is given as $9.^m8$ to $11^m.2$; visually as $9.^m9$ to $11^m.2$. A provisional period of 4.6 day satisfies the observations very well. Its position for 1900 is $\alpha = 2^h\ 6^m.1$, $\delta = +\ 57^\circ\ 37'.6$.

(4) 7.1913 Persei, has the position for 1900 $\alpha = 2^h\ 27^m.0$, $\delta = +\ 58^\circ\ 26'.5$. The range of this star photographically is $9^m.8$ to $11^m.5$. A period of 5.5 days seems to satisfy the data in hand fairly well. It shows no decided color.

(5) 8.1913 Persei seems to have a period of about 450 days, the rise and fall both being extremely gradual. The star ranges from $10^m.6$ to $< 12^m.3$. Visually it rises to about $10^m.1$ and is of a decidedly reddish color. It is in the region slightly south and following α Persei, its exact position being $\alpha = 3^h\ 19^m.7$, $\delta = +\ 49^\circ\ 23'.2$ (1900).

(6) 9.1913 Cephei. $\alpha = 22^h\ 10^m.3$, $\delta = +62°\ 1'.7$ (1900). This star also is probably of long period. Its variability is confirmed by a series of 14 plates taken at Harvard.

A New Variable 10.1913 Cassiopeiae, is announced in *A. N.* 4641, by M. Luizet. This is the star BD. + 60°2629 to which is given the magnitude 9.3. Its position for 1910 is $\alpha = 23^h\ 46^m\ 12^s.9$, $\delta = +60°\ 24'.5$ A discussion of 43 observations shows it without doubt to be a variable of short period of the δ Cephei type. Its range is small, from $9^m.3$ to $9^m.8$ approximately. The elements given to this variable provisionally are:

Min. = 1912 Jan. 12.1 + $4^d.314$ E.

A New Variable Star 11.1913 Persei, is announced in *A. N.* 4648. It is in the region of Nova Persei No. 2 and was discovered in an examination of plates of that star. Its position for 1900 is given as follows: $\alpha = 3^h\ 22^m.4$, $\delta = 44°\ 3'.1$. On March 11 its visual magnitude was $9^m.8$ and since that time it has been becoming fainter. It is apparently a long-period variable with a photographic range of approximateiy $10^m.6$ to $<14^m.0$ Its color is such as to make its visual magnitude about one magnitude brighter.

Observations of Nova (2) Geminorum.—The accompanying observations of Nova (2) Geminorum have been secured between April 10 and May 12, 1913, with my 4-inch equatorial refractor.

OBSERVATIONS OF NOVA (2) GEMINORUM

1913, Apr. 10–May 12.

Date	Mag.	Color	Comparison Stars
Apr. 10	8.4	Light bluish green	BD.+32° 1434, 1442, 1447
Apr. 13	8.4	Light bluish green	BD.+32° 1442, 1447
Apr. 14	8.4	Light bluish green	BD.+32° 1442, 1447
Apr. 15	8.6	Light bluish green	BD.+32° 1434, 1442, 1447
Apr. 16	8.5	Light bluish green	BD.+32° 1434, 1442, 1447
Apr. 17	8.6	Light bluish green	BD.+32° 1434, 1442, 1447
Apr. 18	8.5	Light bluish green	BD.+32° 1434, 1442, 1447
Apr. 19	8.5	Light bluish green	BD.+32° 1434, 1442, 1447
Apr. 20	8.5	Light bluish green	BD.+32° 1434, 1442, 1447
Apr. 21	8.5	Light bluish green	BD.+32° 1434, 1442, 1447
Apr. 22	8.5	Light bluish green	BD.+32° 1434, 1442, 1447
Apr. 23	8.5	Light bluish green	BD.+32° 1442, 1447
Apr. 24	8.6	Light bluish green	BD.+32° 1434, 1442, 1447
Apr. 26	8.6	Light bluish green	BD.+32° 1434, 1442, 1447
Apr. 28	8.6	Very light bluish green	BD.+32° 1434, 1442, 1447
Apr. 29	8.6	Very pale bluish green	BD.+32° 1434, 1442, 1447
Apr. 30	8.6	Very light bluish green	BD.+32° 1434, 1442, 1447
May 1	8.6	Rather light bluish green	BD.+32° 1434, 1442, 1447
May 6	8.6	Very light bluish green	BD.+32° 1434, 1442, 1447
May 7	8.6	Rather light bluish green	BD.+32° 1434, 1442, 1447
May 9	8.6	Light bluish green	BD.+32° 1434, 1442, 1447
May 11	8.7	Light bluish green	BD.+32° 1434, 1442
May 12	8.7	Light bluish green	BD.+32° 1434, 1442

Although a considerable number of observations of the Nova have been possible during the past month, which might be expected to indicate very minutely any changes that have occurred in the star in the course of that time, yet it has, as is seen from the table, been fairly quiet in its behavior. On the whole, however, it has waned slowly since April 10, about 0.3 of a magnitude,* passing, with the exception of two slight fluctuations, very gradually from magnitude 8.4 on April 10 to magnitude 8.7 on May 12. There has been one small variation in the color of the Nova that has taken place in this period which I would also point out. From April 28 through May 7 the star was generally unusually light, on one night in question (April 29) being almost pure white (a very pale bluish green), in hue as far as could be discerned with the telescope. After May 7 it returned to its normal color (light bluish green), and continued there during the remaining observations of this set.

FREDERICK C. LEONARD.

1338 Madison Park, Chicago, Ill.,
1913, May 13.

*Cf. observations in *P. A.* for May, 1913, No. 205, p. 300.

Photographic Charts of Variable Stars.—A supplement to volume V of the Annals of the Observatory of Moscow, Russia, contains reproductions of thirty photographs of the regions around variable stars which have been discovered by Mme L. Ceraski. The charts thus produced are each 80′ square, having the variable indicated by a cross near the center of the chart. Twelve of these stars, SX *Cassiopeiæ*, SY *Andromedæ*, RY *Persei*, RV *Persei*, RY *Aurigæ*, RW *Monocerotis*, RX *Geminorum*, RU *Monocerotis*, RY *Geminorum*, RZ *Draconis*, RR *Delphini* and TT *Andromedæ* are of the Algol type.

RU Camelopardalis a Rotating Ellipsoid.—In the Laws Observatory Bulletin, No. 21, Mr. Harlow Shapley gives the results of a study of the variable star RU Camelopardalis, from which he concludes that this is not an eclipsing binary star, but an ellipsoidal single star rotating upon its shortest axis in a period of 44.344 days. The light passes through all its variations in half of this period. The ratio of the minor axes to the major axis of the ellipsoid is somewhere from 0.42 to 0.62.

COMET AND ASTEROID NOTES.

New Comet 1913 *a* (Schaumasse.)—A telegram from Harvard College Observatory, received May 8, announced the discovery of a comet by Schaumasse at Nice, France, on the morning of May 7. The discovery position was given as

May 6.6082 Gr. M. T. R.A. = $20^h\ 54^m\ 44^s$, Dec = $+\ 9°\ 52'$;

the comet being visible in a small telescope and moving northeast. Observations later showed that the last word was wrong and the motion was northwest. Because of this error and the rapidly approaching dawn we did not find the comet on the morning of May 9, at Goodsell Observatory, but on the 10th it was easily found with

the 5-inch finder. The comet is easily visible with a small telescope, but is not at all conspicuous. It has been increasing in brightness and will reach its maximum early in June, when it will be 2.3 times as bright as when it was discovered. It will still be visible in July. The diagram Fig. 1 shows the path of the comet among

FIG. 1. DIAGRAM SHOWING THE APPARENT PATH OF COMET 1913 *a* AMONG THE STARS.

the stars during May and its approximate course during a part of June. The diagram Fig. 2 shows the relation of the comets orbit to that of the earth. The earth's orbit is projected upon the plane of the comet's orbit, the dotted portion being beyond that plane. These diagrams were made by means of the first preliminary elements telegraphed from the Berkeley Astronomical Department. The later elements change the course of the comet only a little. During June it will pass through the northern part of the constellations Hercules and Boötes, into Canes Venatici; after that its motion will be slower, and southwestward.

The following observations are all that have come to hand at the time of this writing (May 23):

Greenwich M.T.	App. R.A. h m s	App. Dec.	Observer	Place
May 7.6027	20 51 33.47	+10 42 41	Antionazzi	Padua
7.5710	20 51 39.87	+10 41 06	Voûte	Leiden
7.5125	20 51 51.20	+10 38 00	Millosevich	Rome
7.8758	20 50 38.5	+10 57 05	Aitken	Mt. Hamilton
8.5295	20 48 22.5	+11 32 17	Hartwig	Bamberg
9.8234	20 43 36.4	+12 45 04	Hussey	LaPlata
9.8556	20 43 28.89	+12 46 48.2	Wilson	Northfield
9.8663	20 43 26.9	+12 47 29		Mt. Hamilton
11.8093	20 35 24.00	+14 44 42.1	Barnard	Williams Bay
15.8274	20 14 48.08	+19 18 57.5	Wilson	Northfield
22.7248	19 22 01.89	+28 37 20.1	Wilson	Northfield
23.7068	19 12 13.19	+30 00 57.3	Gingrich	Northfield

The following elements are at hand:

Computers		Kiess and Nicholson	Kiess and Nicholson	Wilson and Gingrich
Dates of observation		May 7, 7, 8	May 7, 9, 11	May 7, 11, 15
Time of Perihelion	T	1913 May 17.91	May 16.28	May 15.2314
Perihelion minus node	ω	57° 28′	54° 36′	53° 07′ 12″
Longitude of node	Ω	317 00	315 43	315 06 52
Inclination	i	153 34	152 43	152 22 02
Perihelion distance	q	1.440	1.453	1.4571

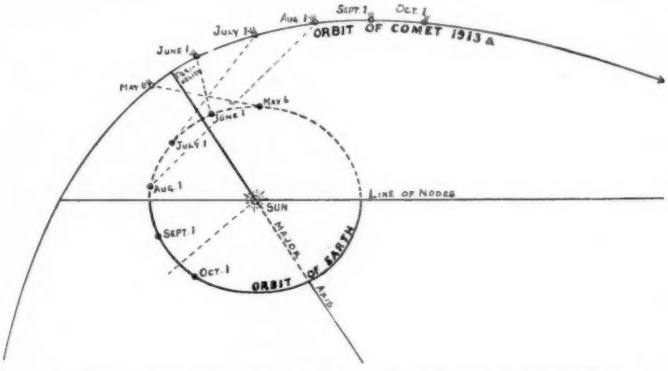


FIG. 2. DIAGRAM SHOWING THE RELATION OF THE ORBIT OF COMET 1913 *a* TO THAT OF THE EARTH.

EPHEMERIS OF COMET 1913 *a*.

(Computed by Kiess and Nicholson from the second set of elements.)

Gr.M.T.	R.A. h	m	s	Dec. °	′	Brightness
May 15.5	20	16	36	+18	56	1.3
19.5	19	49	41	+24	09	
23.5	19	13	40	+29	49	
27.5	18	26	43	+35	17	2.0

Ephemeris of Comet 1913 *a* (Schaumasse.)

[Computed by Miss Myrtle L. Richmond from the elements by Wilson and Gingrich]

1913		α h	m	s	δ °	′	″	log *r*	log Δ	Br.
May	27.5	18	27	58.8	+35	9	37	0.1666	9.8520	2.28
	31.5	17	31	57.3	39	21	4	0.1689	9.8477	2.30
June	4.5	16	31	50.3	41	26	19	0.1718	9.8620	2.12
	8.5	15	36	1.2	41	22	9	0.1753	9.8915	1.82
	12.5	14	50	3.5	30	49	52	0.1794	9.9307	1.49
	16.5	14	14	44.5	37	36	37	0.1839	9.9744	1.20
	20.5	13	48	18.3	35	13	53	0.1890	0.0189	1.00
	24.5	13	28	33.7	32	56	59	0.1944	0.0622	1.76
	28.5	13	13	42.5	30	51	45	0.2003	0.1033	0.61
July	2.5	13	2	25.2	28	59	23	0.2064	0.1418	0.50
	6.5	12	53	46.0	27	19	8	0.2130	0.1774	0.41
	10.5	12	47	5.7	25	49	43	0.2198	0.2104	0.34
	14.5	12	41	56.0	24	29	40	0.2268	0.2409	0.29
	18.5	12	37	57.0	23	17	35	0.2340	0.2690	0.24
	22.5	12	34	53.3	22	12	20	0.2413	0.2949	0.21
	26.5	12	32	34.4	21	12	53	0.2488	0.3188	0.18
	30.5	12	30	52.0	20	18	25	0.2565	0.3409	0.16
Aug.	3.5	12	29	39.8	+19	28	15	0.2641	0.3613	0.14

Ephemeris of Comet 1912 *a* (Gale).—The following ephemeris is given in *A. N.* 4651.

1913	R.A.	Dec.	log *r*	log Δ	Brightness
	h m s	° ′			m
June 1	7 05 42	+44 23,8	0.5636	0.6444	12.8
3	08 05	44 08.6			
5	10 27	43 53.8			
7	12 47	43 39.2			
9	7 15 07	+43 24.9	0.5742	0.6593	12.9

NOTES FOR OBSERVERS.

Monthly Report of the American Association of Variable Star Observers, Apr.-May, 1913.—A number of adverse circumstances have diminished the number of observations made by the members of the association during the past month. Cloudy weather has materially interfered with our work, and Messrs. Forsyth and Ginori were unable to make any observations.

Messrs. Burbeck and Leonard, however, did unusually well, and were able to send in over eighty observations each, a good month's record. It is almost needless to say that Dr. Gray again leads the class with a fine list of 157 observations of 64 variables. The large number of variables observed each month by Dr. Gray adds greatly to the value of the records of the Association, and the extension of our individual observing list is something we should all strive for.

The chart exchange plan is working out admirably. Mr. Lacchini contributed a number of fine blue prints for distribution, and Messrs. Gray, Bancroft, and McAteer have been most generous in distributing blue prints. Before long we should each possess a valuable collection of charts.

Mr. F. W. Waters, of Coburg, Australia, is interested in the work of our association, and may be considered a member of the Association. Distance renders his observations unavailable material for the monthly reports, but Mr. Waters' estimates are all sent to Professor Pickering and thus incorporated in the general contribution of data concerning variables.

That interesting variable 074922 U Geminorum has been under close observation for several months past, and has failed to put in an appearance. It attained a maximum January 14, and none of our observations since record its characteristic rapid increase in brilliance.

Its mean period is about 86 days, according to Gore, and at this writing it is 115 days since it's last maximum. The variable should be closely observed.

154428 R Coronae remains fairly steady—about sixth magnitude—and the many observations of it are well in accord.

072708 S Can. Min. has been closely observed during the past month. There is considerable discord in the observations, more than there should be. Dr. Hartwig's calculated maximum for January 20 appears to disagree with our observations, which indicate a maximum of about 7.5 the last week in March.

132422 R Hydrae appears from the estimates to have reached a maximum of about fourth magnitude the first week in February. The calculated date of maximum was April 17.

A calculated date of maximum of 054974 V Camelopard. for April 20 is at variance with our observations, which indicate that the variable was about the tenth magnitude and waning on that date.

VARIABLE STAR OBSERVATIONS Apr.–May, 1913.

001755
T Cassiop.

Mo.	Day	Est.	Obs.
4	26	11.9	Y
5	1	12.1	J

003179
Y Cephei

Mo.	Day	Est.	Obs.
4	25	9.9	G
	30	10.5	G

004958
W Cassiop.

Mo.	Day	Est.	Obs.
5	1	10.3	J

011272
S Cassiop.

Mo.	Day	Est.	Obs.
5	2	10.5	J

014958
X Cassiop.

Mo.	Day	Est.	Obs.
4	9	11.9	Y
	26	12.3	Y

021558
S Persei

Mo.	Day	Est.	Obs.
4	9	8.2	B
	26	8.0	B

024356
W Persei

Mo.	Day	Est.	Obs.
4	6	9.5	Le
	10	9.5	Le
	13	9.8	Le
	14	9.6	Le
	15	9.6	Le
	16	9.6	Le
	17	9.5	Le
	20	9.7	Le
	21	10.0	V
	23	9.8	Le
	26	9.8	Le
	28	10.1	Le
	29	10.2	Le
	30	10.1	Le
5	1	10.2	Le

030514
U Arietis

Mo.	Day	Est.	Obs.
4	7	9.1	Y

032043
Y Persei

Mo.	Day	Est.	Obs.
4	9	10.1	B

033362
U Camelop.

Mo.	Day	Est.	Obs.
4	9	8.3	G
	10	8.2	G

042215
W Tauri

Mo.	Day	Est.	Obs.
4	1	9.5	G
	6	9.4	G
	8	9.0	Ba
	9	9.3	G
	26	9.3	Y

043065
T Camelop.

Mo.	Day	Est.	Obs.
4	9	8.4	Y
	17	8.5	Y
	26	8.5	Y

043274
X Camelop.

Mo.	Day	Est.	Obs.
4	17	12.3	Y
	23	12.7	Y

045514
R Leporis

Mo.	Day	Est.	Obs.
3	30	8.3	L
4	1	7.4	Bu
	2	7.5	Bu
	8	7.4	Bu
	9	7.2	G

050953
R Aurigae

Mo.	Day	Est.	Obs.
4	7	12.3	J
	9	12.5	B
	23	15.5	Y
	24	12.8	B
5	3	12.8	Y

052034
S Camelop.

Mo.	Day	Est.	Obs.
4	16	8.8	Y
	26	8.8	Y

052036
W Aurigae

Mo.	Day	Est.	Obs.
4	9	10.4	G
	21	9.2	V
	28	9.2	V
5	4	9.1	Ba

053068
S Camelop.

Mo.	Day	Est.	Obs.
4	17	9.1	Y
5	3	9.7	Y

053531
U Aurigae

Mo.	Day	Est.	Obs.
4	7	8.5	Y
	17	8.6	Y
5	3	8.7	Y

054319
SU Tauri

Mo.	Day	Est.	Obs.
4	26	9.8	Y

054615
RU Tauri

Mo.	Day	Est.	Obs.
4	26	12.5	Y

054974
V Camelop.

Mo.	Day	Est.	Obs.
4	10	9.3	G
	24	10.1	G
5	3	11.0	Ba

054920
U Orionis

Mo.	Day	Est.	Obs.
3	30	11.2	L
4	2	10.4	Bu
	8	10.2	Bu

055353
Z Aurigae

Mo.	Day	Est.	Obs.
4	17	10.8	Y
	23	10.8	Y

061702
V Monoc.

Mo.	Day	Est.	Obs.
4	6	7.5	G
	8	7.7	G
	20	7.6	G
	23	7.8	G
	30	7.8	G

062808
Z Monoc.

Mo.	Day	Est.	Obs.
4	23	8.4	G

063159
U Lyncis

Mo.	Day	Est.	Obs.
4	8	11.6	Ba
	21	11.7	Ba
	25	11.7	Ba
	26	11.7	Ba
	30	11.8	Ba
5	2	11.8	Ba

063558
S Lyncis

Mo.	Day	Est.	Obs.
4	9	12.5	Y
	26	12.7	Y
	30	13.8	Ba

064030
X Geminorum

Mo.	Day	Est.	Obs.
5	3	12.5	Y

064932
NOVA GEMIN. 2

Mo.	Day	Est.	Obs.
3	30	8.6	L
4	1	8.9	G
	2	8.5	Bu
	3	8.4	C
	5	8.9	G
	6	8.8	L
	6	9.0	G
	7	8.9	M
	8	8.9	Ba
	8	8.8	Bu
	8	8.5	C
	9	8.6	Bu
	9	8.6	C
	14	8.5	L
	17	8.9	M
	17	9.0	O
	18	8.4	Bu
	18	8.6	Y

NOVA GEMIN. 2

Mo.	Day	Est.	Obs.
4	19	8.9	M
	20	8.6	Bu
	20	9.0	G
	21	8.7	V
	21	8.6	O
	23	8.7	Bu
	24	8.9	M
	24	8.9	G
	25	8.7	O
	25	8.6	Bu
	26	8.6	Bu
	27	8.6	C
	27	8.7	O
	27	8.7	Ha
	28	8.7	V
	28	8.7	Bu
	29	9.0	G
	30	8.8	Ba
5	1	8.8	O
	1	8.7	G
	2	8.8	O
	6	8.7	V
	8	8.8	O

065208
X Monoc.

Mo.	Day	Est.	Obs.
4	6	8.3	G
	8	8.2	G
	10	8.5	G
	18	7.7	G
	20	7.9	G
	23	7.7	G
	29	7.9	G
	30	7.6	G

065355
R Lyncis

Mo.	Day	Est.	Obs.
4	5	9.6	J
	7	9.6	J
	8	9.6	G
	8	9.2	Ba
	9	9.2	B
	17	9.5	Y
	21	9.3	B
	22	9.5	G
	24	9.5	B
	25	9.6	G
	26	9.9	Y
	27	10.4	O
	29	9.7	G
5	1	10.4	J
	2	10.2	Ba

070122a
R Geminorum

Mo.	Day	Est.	Obs.
4	9	12.8	Y
	17	11.0	Hu
	21	11.0	Hu
	26	12.8	B
5	2	12.2	B
	3	12.2	Hu

070310
R Can. Min.

Mo.	Day	Est.	Obs.
3	30	10.5	L
4	5	10.0	G
	6	10.7	L
	8	11.0	Ba

071713
V Geminorum

Mo.	Day	Est.	Obs.
4	23	9.4	G

072708
S Can. Min.

Mo.	Day	Est.	Obs.
3	30	7.7	L
4	5	7.7	G
	6	8.0	L
	7	8.1	M
	7	7.7	B
	8	7.8	G
	9	7.6	Bu
	13	7.8	Ha
	14	8.0	B
	14	7.8	G
	16	8.3	B
	17	8.2	M
	17	7.7	O
	17	8.0	B
	18	7.8	G
	19	8.3	M
	20	7.9	G
	21	8.3	O
	24	7.9	G
	24	8.4	M
	25	7.8	Bu
	25	8.3	O
	27	8.5	Ha
	27	8.5	O
	28	7.6	Bu
	29	8.7	M
	29	8.1	G
	30	8.3	G
	30	8.6	S
5	1	8.5	O
	2	8.3	B
	2	8.6	Ba
	2	9.1	M
	5	8.5	O

073508
U Can. Min.

Mo.	Day	Est.	Obs.
4	8	12.6	Ba
	30	11.5	Ba
5	3	12.0	Y

074922
U Geminorum

Mo.	Day	Est.	Obs.
4	9	13.0	B
5	2	11.5	B

VARIABLE STAR OBSERVATIONS Apr.–May, 1913.—Continued.

081112
R Cancri

Mo.	Day	Est.	Obs.
3	30	8.9	L
4	6	8.7	L
	9	9.0	Bu
	21	8.9	O
	22	8.4	Bu
	23	8.8	V
	24	8.4	Bu
	24	9.0	Hu
	25	8.8	O
	26	8.6	Bu
	29	8.7	V
5	2	9.0	Ba
	2	8.7	O
	3	8.5	Hu
	6	8.3	V
	8	8.7	O

081617
V Cancri

Mo.	Day	Est.	Obs.
4	8	8.7	Ba
	21	9.4	O
	28	9.6	O
5	2	10.0	O
	2	10.0	Ba

082405
RT Hydrae

Mo.	Day	Est.	Obs.
3	30	7.9	L
4	6	7.6	L
	14	7.8	L
	14	7.7	V
	21	7.8	G
	24	7.4	V
	30	7.4	V
5	2	8.0	Ba
	2	8.5	G

084803
S Hydrae

Mo.	Day	Est.	Obs.
4	2	9.2	Bu
	5	9.1	G
	8	9.8	Bu
	9	9.6	B
	10	9.3	G
	17	10.0	B
	21	9.0	Hu
	21	9.9	G
	26	10.5	B
	28	10.6	O
5	1	10.7	G
	3	11.5	Ba

085008
T Hydrae

Mo.	Day	Est.	Obs.
4	8	12.8	Ba

085120
T Cancri

Mo.	Day	Est.	Obs.
3	30	8.8	L
4	23	9.5	V
	24	8.7	Hu
	27	8.5	B
	29	8.7	V
5	2	8.9	Ba
	3	9.6	O
	3	9.1	Hu
	6	9.1	V

093014
X Hydrae

Mo.	Day	Est.	Obs.
4	24	11.7	G

093178
Y Draconis

Mo.	Day	Est.	Obs.
4	9	13.0	Y

093934
R Leo. Min.

Mo.	Day	Est.	Obs.
4	2	9.2	Bu
	8	9.4	Bu
	9	9.4	Bu
	21	9.8	Hu
	25	10.0	Hu
	30	10.2	S

094211
R Leonis

Mo.	Day	Est.	Obs.
3	30	6.6	L
4	6	6.5	Le
	7	6.4	Le
	7	6.6	Le
	8	7.4	C
	9	6.6	Bu
	9	7.5	C
	10	6.9	Le
	13	6.6	Le
	13	6.7	Ha
	14	6.2	G
	14	6.8	L
	14	6.7	Le
	15	6.7	Le
	16	6.7	Le
	17	6.7	B
	17	7.2	M
	18	6.8	Le
	20	6.3	G
	20	6.7	Le
	20	6.4	Bu
	21	6.7	Le
	21	7.2	Y
	22	6.9	Le
	23	7.3	V
	23	6.9	Le
	24	6.5	G
	24	6.9	Le
	24	7.3	M
	25	6.8	B

R Leonis

Mo.	Day	Est.	Obs.
4	25	6.2	Bu
	25	7.2	O
	26	7.0	Le
	26	7.7	S
	27	7.2	Ha
	27	7.6	C
	28	7.4	O
	28	6.2	Bu
	28	7.1	Le
	29	7.0	Le
	29	7.5	M
	29	7.7	V
	30	7.1	Le
5	1	7.3	Le
	2	7.1	B
	2	7.1	Ba
	2	7.5	O
	2	6.8	G
	3	7.5	Y
	4	7.4	M
	5	7.6	O
	6	7.7	V

094622
Y Hydrae

Mo.	Day	Est.	Obs.
4	5	7.0	G
	21	6.4	G
	30	6.5	G

103212
U Hydrae

Mo.	Day	Est.	Obs.
4	3	4.5	C
	8	4.5	C
	9	4.5	C
	9	4.6	Bu
	20	4.4	Bu
	22	5.8	G
	25	4.5	Bu
	27	4.9	C
	28	4.6	Bu

103769
R Urs. Maj.

Mo.	Day	Est.	Obs.
4	7	12.7	B
	8	13.0	Ba
	9	13.2	Y
	20	12.7	M
	23	12.8	Y
	25	12.6	B
	25	12.8	Ba
	29	10.8	J
	30	12.4	Ba
5	1	10.9	J
	2	12.3	Y
	8	10.8	J

104620
V Hydrae

Mo.	Day	Est.	Obs.
4	1	6.5	G
	5	6.3	G
	21	6.5	G
	29	6.4	G

105517
R Crateris

Mo.	Day	Est.	Obs.
4	1	8.5	G
	5	8.5	G
	8	8.6	G
	10	8.4	G
	21	8.4	G
	23	8.3	Le
	24	8.2	Le
	24	8.3	G
	26	8.2	Le
	28	8.1	Le
	29	8.1	Le
	29	8.0	G
	30	8.1	Le
5	1	8.1	Le

110506
S Leonis

Mo.	Day	Est.	Obs.
4	9	11.6	Y
	21	10.9	Y
5	2	10.0	Y

121418
R Corvi

Mo.	Day	Est.	Obs.
4	1	11.5	G
	8	11.5	G
	22	11.3	G
	23	11.1	G
	28	12.6	Hu
	29	11.0	G
	30	12.6	Hu

122001
SS Virginis

Mo.	Day	Est.	Obs.
4	1	7.0	G
	7	7.0	G
	8	7.0	G
	22	7.3	G
	24	7.3	Hu
	25	7.6	O
	30	6.8	Ba
	30	7.2	B
5	2	7.3	G
	2	7.6	O
	5	7.6	O

122532
T Can. Ven.

Mo.	Day	Est.	Obs.
4	17	9.4	Y
	23	9.4	V
	29	9.4	V
5	6	9.4	V

123160
T Urs. Maj.

Mo.	Day	Est.	Obs.
4	9	12.5	B
	9	12.5	Y
	19	12.6	M
	23	12.6	Y
	23	11.4	Le
	25	12.5	Hu
	26	12.6	B
	26	11.4	Le
	28	11.4	Le
	29	11.6	Le
	30	12.7	Ba
	30	11.6	Le
5	1	11.6	Le

123307
R Virginis

Mo.	Day	Est.	Obs.
4	8	7.0	C
	22	7.7	G
	22	6.4	Bu
	23	6.6	Bu
	24	6.6	Bu
	24	7.4	Hu
	24	7.8	V
	25	7.6	O
	26	6.6	Bu
	28	8.0	S
	30	7.9	Ba
	30	7.8	B
	30	8.2	V
5	1	8.1	O
	5	8.6	O
	6	8.5	V
	8	9.2	O

123961
S Urs. Maj.

Mo.	Day	Est.	Obs.
3	30	10.7	L
4	5	10.8	J
	5	11.5	G
	6	10.9	Le
	7	10.9	J
	7	10.8	M
	8	10.2	Bu
	9	10.5	Y
	9	10.6	Bu
	9	10.5	B
	10	11.0	Le
	14	11.0	Le
	15	11.0	Le
	16	10.9	L
	17	11.0	B
	19	11.0	M
	20	10.9	Bu
	21	11.8	J
	21	11.2	Le
	21	11.4	Ba
	23	11.3	Le
	23	11.6	Y

VARIABLE STAR OBSERVATIONS Apr.–May, 1913.—Continued.

S Urs Maj.

Mo.	Day	Est.	Obs.
4	25	10.2	Hu
	26	11.7	Ba
	26	12.0	B
	26	11.3	Le
	28	11.5	Le
	29	11.4	Le
	29	12.1	J
	30	11.4	Le
	30	11.8	Ba
5	1	12.1	J
	1	11.3	Le
	5	11.9	Y
	8	12.2	J

124204
RU Virginis

Mo.	Day	Est.	Obs.
4	22	9.3	G
	24	9.4	V
	24	8.9	Hu
	25	10.0	O
	30	9.6	V
5	6	9.6	V

124606
U Virginis

Mo.	Day	Est.	Obs.
4	6	12.5	Ba
	22	11.5	G
	25	10.5	Hu
	28	10.1	S
	30	10.2	B
5	2	10.0	O
	8	9.8	O

132422
R Hydrae

Mo.	Day	Est.	Obs.
3	30	5.4	L
4	2	5.3	Bu
	5	5.5	G
	6	5.7	L
	8	5.7	C
	8	5.4	Bu
	9	5.4	Bu
	22	6.2	G
	27	6.0	C
	28	6.3	G
	28	5.4	Bu
	30	6.3	G

132706
S Virginis

Mo.	Day	Est.	Obs.
4	6	9.9	L
	15	9.9	L

133273
T Urs. Min.

Mo.	Day	Est.	Obs.
5	4	13.0	Ba

134440
R Can. Ven.

Mo.	Day	Est.	Obs.
3	30	8.7	L
4	6	8.6	L
	7	8.2	M
	8	8.5	Bu
	8	8.5	G
	9	8.4	Bu
	9	8.4	B
	14	8.6	L
	16	7.8	M
	17	8.2	B
	17	7.8	M
	20	7.9	M
	21	8.2	Ba
	24	7.9	M
	24	8.2	Bu
	25	7.9	Hu
	25	8.1	O
	26	7.9	B
	26	8.2	Bu
	28	7.8	Bu
5	1	8.0	O
	2	7.7	M
	2	6.9	G
	3	7.9	Ba

140412
Z Virginis

Mo.	Day	Est.	Obs.
4	26	10.5	Y

141567
U Urs. Min.

Mo.	Day	Est.	Obs.
4	2	8.8	Bu
	5	8.7	J
	7	9.0	J
	9	9.0	Bu
	20	8.8	J
	20	9.0	Bu
	21	9.1	J
	25	8.1	Hu
	26	8.1	S
5	4	8.2	Ba
	8	9.0	J

141954
S Boötis

Mo.	Day	Est.	Obs.
4	7	11.9	B
	8	12.5	Ba
	23	11.1	Y
	25	10.9	B
	26	11.0	Ba
	30	10.9	J
5	2	10.4	B
	3	10.5	Ba
	8	10.0	J

142205
RS Virginis

Mo.	Day	Est.	Obs.
5	2	13.3	Y
	3	13.3	Ba

142539
V Boötis

Mo.	Day	Est.	Obs.
3	30	10.2	L
4	5	10.2	G
	6	10.4	L
	7	10.2	M
	8	10.2	G
	9	10.2	B
	14	10.5	G
	16	10.4	M
	17	10.2	B
	20	10.9	M
	21	10.8	G
	24	10.9	G
	25	10.5	B
	25	10.6	Bu
	26	10.5	S
	26	10.8	Bu
	26	11.0	Ba
	27	10.8	O
	28	10.8	Bu
	30	10.5	G
	30	11.3	Hu
	30	10.7	V
5	2	10.6	B
	6	10.6	V

142584
R Camelop.

Mo.	Day	Est.	Obs.
3	30	8.6	L
4	2	9.0	Bu
	6	8.3	L
	7	9.1	J
	9	8.6	Bu
	16	8.5	L
	17	8.6	O
	21	8.7	J
	24	8.2	Bu
	25	8.3	O
	28	8.2	Bu
	28	8.4	O
	29	8.3	J
5	1	8.3	O
	1	8.4	J
	2	8.3	G
	3	8.2	O
	5	8.2	O
	8	8.1	O
	8	8.1	J

143227
R Boötis

Mo.	Day	Est.	Obs.
4	6	11.7	L
	24	10.0	Hu
	28	9.7	S
5	3	9.7	O
	4	9.4	Ba
	5	9.1	O
	7	9.2	O

150605
Y Librae

Mo.	Day	Est.	Obs.
4	6	11.0	L

151520
S Librae

Mo.	Day	Est.	Obs.
4	9	9.2	Bu
5	4	8.4	Ba

151731
S Cor. Bor.

Mo.	Day	Est.	Obs.
4	5	8.5	G
	8	8.5	G
	21	8.6	Ba
	22	8.7	G
	24	8.6	Bu
	25	8.6	Bu
	25	9.0	O
	26	8.8	Bu
	28	8.8	Bu
	28	9.5	O
	29	9.5	M
	30	8.9	G
5	1	9.4	O
	4	9.0	Ba
	5	9.7	O
	8	10.0	O

151822
RS Librae

Mo.	Day	Est.	Obs.
4	2	10.2	Bu
	9	10.4	Bu
5	4	8.1	Ba

153378
S Urs. Min.

Mo.	Day	Est.	Obs.
3	30	12.0	L

154428
R Cor. Bor.

Mo.	Day	Est.	Obs.
3	30	6.0	L
4	3	5.4	C
	5	6.0	G
	6	6.0	L
	6	5.6	Le
	7	6.0	J
	8	5.6	C
	8	5.8	Ba
	8	6.0	G
	9	5.9	C
	10	5.8	Le
	14	6.1	L
	14	5.8	Le
	16	5.9	Le
	17	5.9	Le
	18	5.8	Le
	20	5.7	Le
	21	5.6	Ba
	21	6.2	O
	21	5.7	Le
	22	6.2	G
	22	5.7	Le

R Cor. Bor.

Mo.	Day	Est.	Obs.
4	23	5.7	Le
	24	6.2	Bu
	25	6.2	O
	25	6.2	Bu
	25	5.6	Hu
	26	5.8	Le
	26	6.4	B
	26	6.0	Bu
	26	6.0	O
	27	5.8	C
	27	6.2	Ha
	28	6.0	G
	28	5.7	Le
	28	6.0	O
	28	6.0	Bu
	29	6.1	J
	29	5.7	Le
	30	5.6	Ba
	30	5.6	Hu
	30	5.8	Le
	30	6.0	G
5	1	5.7	Le
	1	6.2	O
	1	6.0	B
	2	6.2	O
	2	6.0	J
	3	6.2	O
	4	5.6	Ba
	5	6.2	O
	7	6.2	O
	8	6.0	O
	8	6.1	J
	9	6.0	O

154536
X Cor. Bor.

Mo.	Day	Est.	Obs.
4	7	9.3	J
	29	10.1	J
5	8	11.1	J

154639
V Cor. Bor.

Mo.	Day	Est.	Obs.
4	5	8.5	G
	8	8.5	G
	22	8.6	G
	24	8.6	G
	30	8.8	G
5	1	9.4	O
	2	9.2	O
	5	9.1	O
	7	9.3	O
	8	9.3	O

154615
R Serpentis

Mo.	Day	Est.	Obs.
4	1	7.2	G
	26	7.2	Bu
	28	7.2	Bu
5	3	6.4	O
	5	6.6	O
	7	6.6	O

VARIABLE STAR OBSERVATIONS Apr.–May, 1913.—Continued.

155823
RZ Scorpii

Mo.	Day	Est.	Obs.
4	7	7.5	G
	28	7.7	G

155847
X Herculis

Mo.	Day	Est.	Obs.
4	6	6.1	L

162119
U Herculis

Mo.	Day	Est.	Obs.
4	6	8.9	M
	8	8.4	G
	9	8.8	Y
	16	9.1	M
	17	8.9	Y
	22	8.7	G
	29	9.3	M
	30	9.1	G
	30	9.2	S
5	2	9.3	O
	2	9.0	Y
	8	9.3	O

162212
V Ophiuchi

Mo.	Day	Est.	Obs.
4	26	9.2	Bu

163137
W Herculis

Mo.	Day	Est.	Obs.
4	17	8.6	Y
	30	9.0	S
5	2	9.3	Y
	3	9.2	O
	8	9.2	O

163172
R Urs. Min.

Mo.	Day	Est.	Obs.
4	2	10.2	Bu
	8	10.2	Bu
	9	10.4	Bu
	9	10.0	B
	24	10.2	Bu
	26	9.8	B
5	2	10.1	B

163266
R Draconis

Mo.	Day	Est.	Obs.
4	7	12.6	B
	9	12.5	Y
	23	12.5	Y
5	5	12.0	Y

164715
S Herculis

Mo.	Day	Est.	Obs.
4	26	11.5	Y
5	2	11.3	B
	8	11.0	O

165030
RR Scorpii

Mo.	Day	Est.	Obs.
4	7	8.8	G
5	1	8.7	G

165631
RV Herculis

Mo.	Day	Est.	Obs.
4	9	12.9	B
	26	12.0	Y
	29	11.0	M
	30	11.1	B
5	2	11.0	O
	2	11.6	Y
	8	10.9	O

170215
R Ophiuchi

Mo.	Day	Est.	Obs.
4	8	11.5	Bu
5	1	11.2	J
	2	9.8	G

180531
T Herculis

Mo.	Day	Est.	Obs.
4	6	11.0	L
	14	9.3	L
	15	9.3	L
	16	9.4	M
	29	8.8	M
	30	8.7	S

181136
W Lyrae

Mo.	Day	Est.	Obs.
4	9	9.8	Y
	21	9.8	Y
	28	9.7	Le
	29	9.6	Le
	30	9.3	Le
	30	9.9	M
	30	9.8	G
5	1	9.5	Le
	8	9.3	O

184205
R Scuti

Mo.	Day	Est.	Obs.
4	7	5.0	G
	15	6.0	L
	16	5.5	M
	28	5.8	G
	28	5.4	Bu

190926
X Lyrae

Mo.	Day	Est.	Obs.
5	1	9.3	G

193449
R Cygni

Mo.	Day	Est.	Obs.
4	7	8.1	G
	15	8.9	L
	16	9.0	M
	20	9.1	M
	27	9.1	G
	30	9.6	S
	30	9.5	M
5	1	9.2	G
	1	9.3	Le
	2	9.2	G
	3	9.1	Ba

193732
TT Cygni

Mo.	Day	Est.	Obs.
4	30	7.4	G

194048
RT Cygni

Mo.	Day	Est.	Obs.
4	7	7.0	G
	15	8.4	L
	16	8.2	M
	20	8.7	M
	27	8.3	G
	30	8.9	S
	30	9.3	M
5	1	8.4	G
	1	9.0	Le
	3	8.7	Ba

194348
TU Cygni

Mo.	Day	Est.	Obs.
4	20	12.4	M
	30	10.8	G

200647
SV Cygni

Mo.	Day	Est.	Obs.
4	7	8.8	G
	16	9.4	M
	30	9.1	M

200938
RS Cygni

Mo.	Day	Est.	Obs.
4	7	7.5	G
	27	7.3	G
5	1	8.8	J
	8	9.0	J

201008
R Delphini

Mo.	Day	Est.	Obs.
5	1	11.4	J

201647
U Cygni

Mo.	Day	Est.	Obs.
4	7	8.0	G
	15	9.0	L
	20	9.1	J
	27	7.7	G
	29	9.0	J
	30	8.4	S

202539
RW Cygni

Mo.	Day	Est.	Obs.
4	7	8.5	G
	27	8.2	G

202946
SZ Cygni

Mo.	Day	Est.	Obs.
4	28	9.4	Le
	29	9.4	Le
5	1	9.5	Le

203847
V Cygni

Mo.	Day	Est.	Obs.
4	27	11.5	G
	28	11.5	G
5	2	10.6	J

205923
R Vulpeculae

Mo.	Day	Est.	Obs.
5	1	9.0	J
	8	9.2	J

210868
T Cephei

Mo.	Day	Est.	Obs.
4	7	9.8	J
	7	9.4	B
	15	9.6	L
	21	9.3	J
	24	9.6	Bu
	26	8.7	B
	28	9.2	S
	29	9.0	J
5	8	9.0	J

213244
W Cygni

Mo.	Day	Est.	Obs.
4	15	5.5	L
	24	5.8	Bu
5	1	6.1	G

213678
S Cephei

Mo.	Day	Est.	Obs.
4	7	8.9	B
	7	10.5	J
	21	8.6	B
	21	10.5	J
	26	8.6	B
	28	9.7	S
	29	10.7	J

213753
RU Cygni

Mo.	Day	Est.	Obs.
4	28	8.7	G

213743
SS Cygni

Mo.	Day	Est.	Obs.
4	15	11.9	L
	20	12.2	M
	28	11.7	G
	28	11.4	Le
5	1	11.6	G
	1	11.9	J
	2	11.7	G
	2	11.9	J
	3	12.1	Ba
	4	12.1	Ba
	8	11.9	J

213937
RV Cygni

Mo.	Day	Est.	Obs.
4	7	7.5	G
	24	8.2	Bu
	28	7.7	Le
	28	7.7	G
5	1	8.2	J
	1	7.5	Le
	2	7.6	G

230759
V Cassiop.

Mo.	Day	Est.	Obs.
4	30	7.7	G
5	1	7.9	J

235182
V Cephei

Mo.	Day	Est.	Obs.
4	5	6.8	G
	8	6.5	C
	8	6.8	G
	24	6.7	G
	27	6.6	C
	30	6.5	G

235350
R Cassiop.

Mo.	Day	Est.	Obs.
5	1	11.8	J

No. of observations, 835; No. of stars observed, 118; No. of observers, 15.

The same may be said of 084803 S Hydrae, with a calculated date of maximum April 1. The variable on that date appears to have been about ninth magnitude and waning.

These statements as to disagreements in the calculated and observed dates of maxima are in no sense intended as criticism. They are mentioned merely to indicate that these variables are irregular, and consequently deserving of close observation.

Mr. Jacobs in observing, 201008 R Delphini May 1 seems to have narrowly escaped discovering the new comet, which was first seen May 6 in R. A. 20^h 54′, Dec. + 9° 52′.

In conclusion, the secretary wishes to thank the members of the Association for sending in their lists promptly, and for their interest and coöperation in the work and its extension.

WM. TYLER OLCOTT
Corresponding Sec'y.

Norwich, Ct., May 10, 1913.

Jupiter's North Equatorial Belt.—Professor A. Thos. G. Apple, of the Daniel Scholl Observatory, Lancaster, Pa., reports that a number of recent morning observations of Jupiter have shown the North equatorial Disturbance to be to some extent renewed, presenting again somewhat of the knotted appearance which was remarked last fall. The belt itself continues about the same width, fading gradually toward the north. The most significant change is that it has become a decided pink or reddish color, while the southern belts have become an olive brown.

Dr. Edward Gray, of Eldridge, Cal., has been appointed director of the Variable Star Section of the Society for Practical Astronomy, to succeed Mr. W. T. Olcott, of Norwich, Ct., who resigned on account of the heavy work connected with his position as corresponding secretary of the American Association of Variable Star Observers. Mr. Olcott will continue in this latter position, in which he is doing most efficient service, as shown by the great increase in the number of variable star observations which have been published in this department of POPULAR ASTRONOMY during the past year.

COMMUNICATIONS AND QUESTIONS.

The Astronomical Society of Los Angeles.—On the evening of April 8, there was held in one of the rooms of the Los Angeles High School the fifth meeting of the Astronomical Society of Los Angeles. This new society held its first regular meeting on December 10, 1912.

Connected with the day and night school is a "social center" which was brought into being for the purpose of bringing about a closer social relation among students of that high school.

In this social center there was organized a Civics club and two others, one of which the title of this article names. It was desired that an astronomical society should be organized as one of the divisions of that center. So, through the enthusiasm of Professor W. H. Knight, of this city, Professor Melville Dozier, assistant superintendent of schools, Mr. T. T. Smith, connected with a scientific association, and Messrs. C. C. Kelso and D. S. Swan, teachers in the Los Angeles High School, the organization of the worthy little society was brought about.

The main purpose of this society is to popularize astronomy as much as possible in this section. At each meeting, which occurs on the second Tuesday of every month, there are thirty to forty persons present. This number might be considered as small, but the attendance continues to increase. At present the society has no

elected officers or members, nor a treasury; the necessary officers will be elected at the next meeting. During the last five meetings one of the above mentioned has been acting as chairman. Being, as it is, partly a popular affair, it is appreciated very much, as is shown by the ever increasing interest which some of those who attend are able to take in its proceedings. Unlike certain state or world wide astronomical socities, with their more or less private meetings, this new little society invites the public. Consequently at its meetings there can be found in the audience the curious up to the professional.

The general procedure of the society's meetings, so far, is simple. It frequently occurs that talks on subjects in the descriptive side of astronomy are given by volunteers or by those appointed at some previous time. Discussions and queries occupy part of the time during the general three-hour sessions. As time passes it is hoped, by all those anxious to see it succeed, that it will by degrees rise in rank to one of mark.

GILBERT LANHAM.

Los Angeles, (Hollywood), California.

A Bright Meteor.—On the morning of May 6, at 1:40, I saw quite a remarkable meteor. It seemed to come from a point about 7° or 8° north of Cassiopeiae, and it shot across that constellation towards the southeast, leaving a whitish trail lasting about five or six seconds. It burst into several fragments, one of the fragments also exploding. As it went down behind a line of trees, I could not see the last end of it. As to brilliance, it very much exceeded Venus at her brightest. Objects for some distance around were lighted up quite brightly. One feature of the phenomenon was the peculiar greenish light which it exhibited.

FOREST H. SPINNEY.

Hudson, N. H., May 7, 1913.

A Bright Meteor.—I saw a most beautiful and large meteor pass over the north east part of this city at 8:48 on the evening of May 6. The meteor started from a point about half way from the horizon to the pole in the downward direction of Vega. It was of of a brilliant orange color, with a tinge of lilac. The head separated into two just before it vanished, leaving a slight trail.

Air quiet; sky all clear; temperature 46.

H. W. GRIGGS.

Milwaukee, Wis., May 8, 1913.
2421 Sycamore Street.

Eclipse of the Moon 1913 March 21.—Although I gave but scant attention to the eclipse, the following note may be of interest (See May Number p. 278, last paragraph of Professor E. E. Barnard's letter.)

$17^h\ 20^m$ P. S. T. Edge of shadow near moon's center. A dark eclipse!! The eclipsed area is faintly visible to my naked eye, easier in binoculars. $17^h\ 55^m$; strong dawn. Less than $\frac{1}{10}$ of the disk in the shadow at N. W. limb. $18^h\ 7^m$ moon setting behind the mountains, has passed out of the shadow and is very ruddy from the combined effect of penumbra and low altitude.

HIBBERT PERCEVAL NEWTON.

Irvine's Landing, B. C., Canada.
May 17, 1913.

GENERAL NOTES.

Remember that the next number of POPULAR ASTRONOMY will not be issued unti the latter part of July.

Professor Luis G. Leon, for many years General secretary of Astronomical Society of Mexico, died April 23, 1913, after a long and painful illness, at the age of 47 years. He was very much interested in astronomy and did much, as secretary and as editor of the Bulletin of the Astronomical Society, to keep up popular interest in Astronomy in Mexico.

The Adams Prize of the University of Cambridge has been divided in equal shares between Mr. S. B. McLaren and Dr. J. W. Nicholson. Mr. McLaren submitted an essay on "The Theory of Radiation," Dr. Nicholson one on "The Fundamental Spectra of Astrophysics."

Professor C. J. Keyser, of Columbia University, delivered the annual lecture before the Minnesota chapter of the Sigma Xi on April 24. His subject was "Concerning the Figure and the Dimensions of the Universe of Space."

Mr. A. S. Eddington, chief assistant at the Royal Observatory, Greenwich, has been elected to the Plumian professorship of astronomy in the University of Cambridge, in succession to the late Sir George Darwin.

Professor Thomas C. Chamberlin, head of the department of geology in the University of Chicago, and Professor Forest R. Moulton of the department of astronomy and astrophysics, are members of a special committee of the Illinois Academy of Science appointed to recommend a revision of the present Julian calendar. (*Science*, April 25.)

Mr. A. R. Hinks, of the Cambridge Observatory, Gold Medalist of the Royal Astronomical Society, has been appointed to the professorship of astronomy in Gresham College, London, to fill the vacancy caused by the death of Mr. S. A. Saunders. (*Journal of the British Astronomical Association*, March, 1913.)

Dr. Joseph H. Moore, Acting Astronomer in the Lick Observatory, in charge of the D. O. Mills Expedition to the Southern Hemisphere at Santiago, Chile, during the past four years, will return to Mount Hamilton as Assistant Astronomer late in the summer of 1913.

Dr. Ralph E. Wilson, who has been an Assistant in the Lick Observatory during the past two years, has been appointed Assistant Astronomer in charge of the D. O. Mills Expedition in succession to Dr. Moore.

Dr. Wilson and Miss Mary Adelaide McDonald were married in the Library of the Lick Observatory on May 20th. Mrs. Wilson, it may be said, was the first child born to Lick Observatory parents, and her home has been continuously on Mount Hamilton. Dr. and Mrs. Wilson will sail from San Francisco on June 30th by Pacific Mail S. S. "Pennsylvania" for Panama and Valparaiso.

Mr. Roscoe F. Sanford, who was Carnegie Assistant in the Lick Observatory for two years, Assistant to Astronomer Tucker for three years in the Carnegie Meridian Observatory in the Argentine Republic, and for the past two years Assistant in the work of the D. O. Mills Expedition, has been appointed Assistant Astronomer for continued Service at Santiago, Chile.

Miss Ruth Standen, Secretary of the Lick Observatory, has been granted six months leave of absence for travel in Europe in the iatter half of this year. Miss Clarice L. Davis has been appointed Secretary *ad interim.*

Dr. Louis A. Bauer, of the Carnegie Institution at Washington will deliver the Halley lecture at Oxford, May 22, on "The Earth's Magnetism." (*Nature.*)

Dr Eli Stuart Haynes has been appointed Martin Kellogg Fellow in the Lick Observatory for the academic year 1913-14, with residence at Mount Hamilton.

Dr. Haynes was on the staff of the Laws Observatory, University of Missouri, for several years. During the past two years he has been a graduate student in the University of California, and during the current year an instructor on the staff of the Students' Observatory. His thesis, in completion of requirements for the degree of Doctor of Philosophy in the University of California, relates to the orbit of the minor planet 1911 MT (719) *Albert.* An abstract of this thesis appears in the current number of *Publications of the Astronomical Society of the Pacific.*

Mr. Clifford C. Crump, graduate student in astronomy in the University of Michigan, and student assistant in the Detroit Observatory, has been appointed Fellow in the Lick Observatory for the academic year 1913-14.

Dr. Paul Willard Merrill, Assistant in the Lick Observatory during the years 1909-10 and Fellow in the Lick Observatory during the academic years 1910-13, has been appointed instructor in astronomy in the University of Michigan. Dr. Merrill's thesis, in completion of requirements for the degree of Doctor of Philosophy in the University of California, conferred on May 14, related to the "Class B Stars whose Spectra contain bright Hydrogen Lines." An abstract of this thesis appears in the current number of the *Publications of the Astronomical Society of the Pacific,* and the thesis in full will form a Lick Observatory Bulletin.

Dr. Carl Clarence Kiess, Fellow in the Lick Observatory during the academic years 1910-13, has been appointed instructor in astronomy in the University of Missouri. His thesis, in completion of requirements for the degree of Doctor of Philosophy in the University of California, conferred on May 14, is based upon an investigation of the cluster variable RR Lyræ. An abstract of the thesis appears in the current number of the *Publications of the Astronomical Society of the Pacific,* and the thesis will form the contents of a Lick Observatory Bulletin.

Dr. Emma Phoebe Waterman, Vassar College Fellow in the Lick Observatory during the academic year 1912-13, has been appointed assistant in the Argentine National Observatory at Cordoba. Her thesis, in completion of requirements for the degree of Doctor of Philosophy in the University of California, conferred on May 14, consisted of a study of the visual region of spectrum in the brighter Class A stars of the northern sky. An abstract of the thesis results appears in the current number of the *Publications of the Astronomical Society of the Pacific,* and the thesis as a whole will be published as a Lick Observatory Bulletin.

Mr. John Himes Pitman, Joshua Lippincott Fellow in the Students' Observatory, University of California, during the academic year 1911-12, and Fellow in the Lick Observatory during the current year, has been appointed instructor in mathematics and astronomy in Swarthmore College.

New Buildings for Lick Observatory.—The Legislature of California has unanimously appropriated the sum of $50,000 to cover the construction of a three-story concrete dormitory and two frame residences, in replacement of residence space destroyed by the earthquake of July 1, 1911. Expenses on account of minor damages to substantially all the buildings on Mount Hamilton, to the clocks, domes, etc., in excess of the above amount have been met from other funds. The new residence space will be ready for occupation in June. W.W.C.

Miss Myrtle L. Richmond, Fellow in Astronomy and Mathematics at Goodsell Observatory has been appointed as a computer in the Mount Wilson Solar Observatory. She will begin her work at Pasadena on July 1.

Dr. C. H. Gingrich, associate editor of POPULAR ASTRONOMY, will spend the summer vacation in Europe, and plans to attend the meeting of the International Union for Solar Research at Bonn Aug. 1-5, and the meeting of the Astronomische Gesellschaft at Hamburg Aug. 6-9.

A Fellowship in astronomy and mathematics at Goodsell Observatory will be available September 1. Candidates should be college graduates whose electives have been largely in mathematics.

The Langley Medals.—A tablet in honor of Dr. Samuel Pierpont Langley, at one time director of the Allegheny Observatory and later Secretary of the Smithsonian Institution was unveiled in the Smithsonian Institution on May 6. Addresses were made by Dr. Alexander Graham Bell and Dr. John A. Brashear. At the same time Langley medals were awarded to M. Gustave Eiffel and Mr. Glenn H. Curtiss. Later in the afternoon the Aero Club of Washington arranged hydro-aeroplane maneuvers on the grounds of the Army War College in honor of Dr. Langley.

Well-known as an astronomer, Dr. Langley was also much interested in other branches of physical science, and was a pioneer in the study of aeronautics, having produced a successful model aeroplane. Although the attempted flight of his large aeroplane, carrying a man, proved a failure, the machine was constructed on the same principles as those which were afterward successful at the hands of others.

Anniversary Meeting of the National Academy of Sciences.—The National Academy of Sciences celebrated the semi-centennial anniversary of its foundation on April 22, 23 and 24, exactly fifty years after its first meeting. Addresses were given by Dr. Ira Remsen, the president of the academy, President Arthur T. Hadley, of Yale University, Dr. Arthur Schuster, secretary of the Royal Society of London, Dr. George E. Hale, director of the Mt. Wilson Solar Observatory, Dr. J. C. Kapteyn, director of the astronomical laboratory of the University of Groningen and Dr. Theodor H. Boveri, of the University of Wurzburg. Dr. Hale's address was on "The Earth and Sun as Magnets," and Dr. Kapteyn's address on "The Structure of the Universe."

A Fixed Date for Easter.—In *l'Astronomie* for March 1913 the noted French astronomer discusses anew the question of a fixed date for the celebration of Easter. On the present plan the range of dates for Easter extends in different years from March 22 to April 25. Flammarion suggests the date midway between these, April 8, as the date which it would be the most natural to adopt, but, as Easter should be observed on Sunday, it might be best to take the Sunday nearest to April 8, which would allow Easter to fluctuate only between the dates from April 5 to 11. Should the plan ever be adopted to fix the days of the week and month in successive years by the plan suggested by Professor Grosclaude (See POPULAR ASTRONOMY, No. 194, p. 232), by omitting the 365th or the first day, and the 366th or the 183rd day in leap years, in the count of days in the week and month, reckoning them simply as holidays, then the date of Easter might be absolutely fixed.

Meteoric Dust as a Measure of Geologic Time.—Under this title Mr. Alfred C. Lane, of Tufts College, Mass., presents a short article in *Science* for May 2, 1913. By making certain not unreasonable assumptions as to the size and number of meteors which strike the earth each year, and assuming that the redness of red clay may be due to cosmic dust slowly added from the fall of meteors, he calculates that it would take 8,700 years to accumulate the amount of nickel which is found in one meter thickness of red clay. Five hundred feet of red clay would represent the accumulation of 13,000,000 years, which is surprisingly near the estimates of geologic time by other methods. He urges members of Arctic and Antarctic expeditions, or any one in snowy climates, to complete Nordenskjold's observations, by finding the amount of cosmic dust in a large amount of snow, accumulated in a known time, determined by annual rings or otherwise.

Fireballs and Shooting Stars.—In the *Monthly Notices* of the R.A.S. for March 1913, Mr. W. F. Denning gives the following table, containing the results of his computations of the heights and velocities of bright meteors during the past past twenty-seven years. He says that for most of the systems the number of meteors utilized is perhaps too small to yield dependable averages, but in the instances of the Perseids and Leonids the results are ample. The Leonids are usually about two miles higher than the Perseids, owing probably to their greater velocity, the observed rates being 47.9 and 38.8 miles per second respectively, which is near the theoretical values 44 and 39 miles.

Date.	Name of Shower.	Radiant Point.		No. of Meteors.	Height Beginning	Height Ending	Length of Path	Velocity per Second	No. of Meteors for Velocity
		°	°		miles	miles	miles	miles	
Jan. 1-4	Boötids	231	+52	8	63.0	50.0	65.0	23.0	8
Apr. 18-24	Lyrids	271	+33	7	82.3	51.4	57.0	32.7	6
April	Virginids	209	− 8	7	61.6	48.1	59.7	18.4	5
June-July 8	Scorpiids	252	−22	7	59.1	42.7	97.9	16.0	6
July 15-Aug. 1	Capricornids	305	−11	10	60.9	44.7	44.2	15.0	7
July-Aug.	Perseids	45	+57	76	81.2	53.4	47.8	38.8	43
July 28-Aug 11	Aquarids	339	−11	7	61.6	47.0	66.1	18.6	5
September	β Piscids	346	+ 3	6	72.3	38.3	82.8	19.2	3
October	Arietids	Several		7	78.0	37.4	75.9	21.2	5
November	Taurids	Several		18	71.1	43.4	61.7	24.0	17
Nov. 12-17	Leonids	151	+23	34	82.7	55.7	54.1	47.9	21
Dec. 9-16	Geminids	110	+33	9	75.5	45.5	59.6	24.6	6

Mr. Denning says that "slow meteors from radiants low in the English sky, like the Virginids, Scorpiids, Capricornids, Aquarids, etc., with apparent radiants preceding the apex of the earth's way about 90°, usually have heights of from 67 to 44 miles, and rather long flights of 60 to 100 miles.

"The slow meteors with tolerably high radiants often penetrate the atmosphere until within 25 to 30 miles of the earth's surface. Swift-streaking meteors like Perseids and Leonids very rarely descend lower than 45 miles."

From observations of 550 fireballs and shooting stars Mr. Denning finds the average height at appearance to be 72.1 miles; at disappearance 46.3 miles; average length of path 60.4 miles. From 397 meteors of all sorts the average velocity comes out 27.3 miles (parabolic velocity being 26.2 miles per second). Mr. Denning thinks it is rare for the height of a meteor, when it first becomes visible to the eye, to exceed 100 miles. Some meteors have much greater than parabolic velocities, reaching even to 100 miles per second, while others are much slower.

With regard to the streaks or trains left by certain bright meteors, Mr. Denning finds that their altitude is usually 65 to 50 miles. From observations of 19 such trails he finds the average drift to be slightly more than two miles per minute. In certain instances the drift was much more rapid, ranging between 200 and 400 miles per hour.

Publications of the Observatory of Santiago, Chile.—Publication No. 5 of the Observatory at Santiago, Chile, prepared under the direction of Dr. F. W. Ristenpart contains very convenient tables for reducing star places from the epoch 1925 to the epochs 1900 to 1924. These tables are complementary to those in Publication No. 1, which were for the reverse reduction.

Irregularities in Atmospheric Refraction.—In Vol. III, No. 1, of the Publications of the Allegheny Observatory Professor Schlesinger gives the results of a recent investigation of the irregularities of atmospheric refraction which persist for a longer time than those which have a period of a second of time more or less, with which every observer is familiar. He finds from a study of a number of photographs of star trails, taken for the special purpose, that these plates "not only show the well known rapid oscillations called 'unsteady seeing,' but they confirm the presence of the much slower oscillation that was detected by Nusl and Fric, having a period that is of the order of one minute, and a double amplitude of about one second of arc. Oscillations of intermediate rapidity are also shown; these and the one-minute oscillations affect two neighboring stars precisely alike, up to distances of at least twenty minutes of arc."

Observatory of the Astronomical Society of France.—The observatory of this society was founded as the result of a suggestion made by Camille Flammarion in 1879, and the first dome was built upon the top of the "Hotel des Sociétés Savantes," 28 rue Serpente, Paris, in 1889. In 1900 the building was remodeled and a second dome was erected. The present aspect of the building is shown in the Frontispiece (Plate XXI) to this number of POPULAR ASTRONOMY. The telescopes housed in the two domes are refractors of 4½ and 7½ inches aperture. The purpose of the observatory is to popularize astronomy and it is open to all the members of the Society. Volume I of its "Observations et Travaux," published in 1912, contains photographs of the observatory and telescopes, drawings of sunspots and the planets, and results of various observations made in 1911-12.

Position of the Axis of Mars.—In the Lowell Observatory Bulletin, No. 56, Mr. Percival Lowell gives the results of measures of positions of the South Polar cap of Mars, made at the 1911 opposition by himself and Mr. E. C. Slipher. The results accord closely with those obtained at the preceding oppositions. The weighted mean for the last five oppositions gives for the position of the North Pole of Mars R.A. 315°.42, Decl. 53°.99 and for the inclination of the equator to the plane of the orbit of Mars 23°.47. It appears thus that the obliquity of Mars' ecliptic is almost exactly the same as that of the earth's ecliptic.

The 100-inch Reflector.—We are delighted to learn from a statement in the April 1913 number of the *Publications of the Astronomical Society of the Pacific*, that the source of difficulty in the testing of the great disk of glass in the shops of the Mt. Wilson Observatory has finally been located, and that recent tests prove more satisfactory. A quotation from a personal letter from Mr. Walter S. Adams states that the "last tests proved conclusively that when the glass is properly supported the figure rotates perfectly with the disk. In view of these tests we have already accepted the disk and made payment for it, and are going forward with our plans on the dome and mounting of the telescope." Astronomers the world over will rejoice in this good news.

The Date of the Death of Christ.—In a little pamphlet just issued Mr. Pio Emanuelli, of Rome, Italy, discusses the possible dates of the Crucifixion of Christ, from the point of view of the astronomical conditions. His conclusion is that the death of Jesus Christ occurred on April 7, 1883 years ago, i. e. in the year A.D. 30, and that the age of Christ was about 34 years.

Variations of the Light of Eros and the other Asteroids.—In the *Annals of Harvard College Observatory*, Vol. 72, No. 5, Professor Solon I. Bailey gives the results of his observations of Eros and twenty-two other asteroids in the years 1902-04, with a view to determining their variations in brightness. From a long series of observations, both photometric and photographic, made at Arequipa, Peru, he finds that Eros in 1903 varied quite regularly, the range being a little over half a magnitude, with a period of $5^h\ 16^m$. The light curve closely resembles a sine curve and the maxima are well represented by the formula

$$\text{Max.} = \text{J.D. } 2416090.778 + 0^d.2196\ E.$$

Of the other asteroids which were observed only (30) Urania, (108) Hecuba, (116) Sirona, (186) Celuta and (345) Tercidina exhibit evidence of probable regular variation. For Urania and Hecuba the range is too small and the observations too few to determine the period. For Sirona the range is about a half magnitude and the period about four tenths of a day.

$$\text{Max.} = \text{J.D. } 2415964.300 + 0^d.403\ E.$$

For Celuta observations on three nights indicate a range of a half magnitude in a period of eight hours.

$$\text{Max.} = \text{J.D. } 2416664.343 + 0^d.364\ E.$$

For Tercidina the range is less than a half magnitude and the period about eight hours.

$$\text{Max.} = \text{J.D. } 2415964.430 + 0^d.366\ E.$$

Prizes of the French Academy.—Below is given a list of the awards of the prizes of the French Academy of Sciences. A list of the awards of the Lalande Prize from 1803-1881 is given in *Sidereal Messenger*, Vol. I, pp. 100-102. The award for 1881 is ascribed incorrectly to Sir David Gill. The actual award was made to Dr. Lewis Swift fot his comet discoveries, the Valz prize being awarded to Sir David Gill for his determination of the solar parallax. The lists of the awards of prizes other than the Lalande are complete as far as I have knowledge.

THE LALANDE PRIZE.

Year	Recipient	For what awarded
1881	L. Swift	Comet discoveries
1882	Souillart	Researches on theory of Jupiter's satellites
1883	de LaGrye de Bernardieres Courcelle-Senueil Fleurais Hatt Perrotin Bassot Bigourdan Callandreau	Observations of the transit of Venus
1884	Radau	Memoir on the theory of astronomical refraction
1885	Thollon	Work on the solar spectrum
1886	Backlund	Work on the motion of Encke's comet
1887	Dunér	Researches on double stars and stars of type IIIb
1888	J. Bossert	Collected computational work
1889	Gonnesiat	Contributions to astronomy of precision
1890	Schiaparelli	Work on rotation of Mercury and Venus
1891	Bigourdan	Micrometric measures of nebulae
1892	E. E. Barnard	Discovery of fifth satellite of Jupiter
	M. Wolf	Discoveries of asteroids
1893	Schulhof	Researches on comet orbits
1894	Javelle	Discoveries of nebulae
1895	M. Hamy	Researches in celestial mechanics
1896	P. Puiseux	Work in selenography
1897	C. D. Perrine	Comet discoveries
1898	S. C. Chandler	Work on variation of latitude and variable stars
1899	W. R. Brooks	Comet discoveries
1900	Giacobini	Comet discoveries
1901	Thome	Catalogue of southern stars
1902	Trépied	Photographic chart of the sky—Eros observations
1903	W. W. Campbell	Researches in stellar spectroscopy
1904	S. W. Burnham	Discoveries of double stars
1905	W. H. Pickering	Discovery of ninth and tenth satellites of Saturn
1906	R. G. Aitken W. J. Hussey	Discoveries of double stars
1907	T. Lewis	Catalogue and observations of double stars
1908	W. L. Elkin F. L. Chase	Work on stellar parallaxes
1909	Borrelly	Observations with the meridian circle and micrometer
1910	Cowell Crommelin	Researches on Halley's comet
1911	L. Boss	General catalogue

1912	H. Kobold C. Wirtz	Positions of nebulae

THE VALZ PRIZE

1877	Paul Henry Prosper Henry	Charts to facilitate search for minor planets
1878	J. Schmidt	Selenographic work
1879	Trouvelot	Work on Jupiter, Saturn and Mars
1880	Tempel	Comet discoveries
1881	D. Gill	Determination of solar parallax
1882	W. Huggins	Spectrographic researches
	Cruls	Study of the spectrum of the comet of 1882
1883	Stephan	Discoveries of nebulae
1884	Ginzel	Researches on secular acceleration of mean motion of the moon
1885	Spoerer	Work on sun spots and solar rotation
1886	Bigourdan	Work on personal equations
1887	Périgaud	Study of flexure in meridian circle work
1888	E. C. Pickering	Work on stellar magnitudes
1889	Charlois	Orbits of seven asteroids
1890	Glasenapp	Work on double stars
1891	Vogel	Spectrographic researches
1892	Puiseux	Work in astronomy of precision
1893	Berberich	Theoretical researches on asteroids
1894	Coniel	Computation of asteroid orbits
1895	Denning	Work on meteors and comet discoveries
1896	Bossert	Catalogue of 3950 stars
1897	Fabry	Researches on comet orbits
1898	Colin	Latitude work
1899	Nyrén	Meridian observations
1900	Verschaffel	Meridian observations and catalogue
1901	C. Andre	Treatise on stellar astronomy
1902	Hartwig	Collected works
1903	Borrelly	Comet discoveries
1904	de Campos Rodrigues	Meridian observations
1905	Giacobini	Comet discoveries
1906	J. Palisa	Discoveries of asteroids
1907	Giacobini	Comet discoveries
1908	M. Luizet	Work on variable stars
1909	de LaBaume-Pluvinel	Researches on the the constitution of comets
1910	S. Javelle	Works on nebulae and comets
1911	Rambaut	Contributions to astronomy of precision
1912	A. Schaumasse	Comet discoveries

THE JANSSEN MEDAL

1887	Kirchoff	Contributions to spectral analysis
1888	W. Huggins	Contributions to celestial spectral analysis
1889	N. Lockyer	Contributions to spectral analysis
1890	C. A. Young	Discovery of the infra-chromospheric layer
1891	Rayet	Study of the spectra of solar prominences
1892	Tacchini	Work on solar spectroscopy

1893	S. Langley	Study of solar radiation
1894	G. Hale	Method of isolating single radiations and work on solar prominences and faculae
1895	Deslandres	Contributions to stellar spectroscopy
1898	Belopolsky	Study of radial velocities
1900	Barnard	Discovery of fifth satellite of Jupiter
1902	de LaBaume-Pluvinel	Contributions to solar physics
1904	Hansky	Contributions to actinometry and researches on solar radiation
1905	G. Millochau	Contributions to solar physics
1906	A Ricco	Study of sunspot, faculae and prominences
1908	P. Puiseux	Photographic atlas of the moon
1910	W. W. Campbell	Spectrographic researches
1912	Perot	Researches in spectroscopy

DAMOISEAU PRIZE

1879	Souillart	Researches on eclipses of Jupiter's satellites
1882	Schur	Determination of the mass of Jupiter
1886	Souillart	Researches on the satellites of Jupiter
	Obrecht	Study of the eclipses of Jupiter's satellites
1891	Gaillot	Collected researches
	Callandreau	Researches on Jupiter's family of comets
	Schulhof	Researches on cometary orbits
1892	Radau, Leveau	Researches on long period inequalities in the motion of the moon
1894	Brendel	Study of the perturbation of the asteroids
1897	H. Struve	Calculation of the elements and inequalities in the ring and satellites of Saturn and the satellites of Neptune and Mars
1898	G. W. Hill	Researches in celestial mechanics
1900	J. von Hepperger	Theoretical study of meteors
1902	Gaillot	Researches on the periodic perturbations of Jupiter and Saturn
1905	Fayet, Fabry	Researches on comet orbits of high eccentricity
1911	Millosevich, Witt, Logarde	Work on orbit of Eros

DE PONTECOULANT PRIZE

1903	H. Andoyer	Researches on lunar theory and asteroids
1905	J. C. Kapteyn	Work on stellar motions
1907	Gaillot	Tables of Saturn
1909	E. W. Brown	Work on lunar theory
1911	Schulhof	Study of comet orbits

PIERRE-GUZMAN PRIZE

1905	Perrotin	Collected works
1910	M. Loewy	Collected works

RALPH E. WILSON.

Parallax of the Nebula N.G.C. 221.—In *A. N.* 4650 Mr. Gustaf Strömberg, of Stockholm, Sweden, gives the results of measures for the parallax of the Nebula N. G. C. 221. This nebula is the little round nebula directly north of the center of the great Andromeda nebula, just at the edge of the outer whorl of the latter. From measures of 50 plates (the same which were used by Professor Karl Bohlin in determining the parallax of the nucleus of the Andromeda nebula) Mr Strömberg finds the parallax of the small nebula to be $+ 0''.073 \pm 0''.055$.

The proper motion of the nebula comes out $- 0''.065 \pm 0''.055$ in right ascension and $+ 0''.144 \pm 0''.041$ in declination.

Orbit of the Double Star β 101.—In *A. N.* 4649 Mr. W. Doberck gives the following elements of the orbit of the double star β 101, depending upon observations from 1875 to 1904. In this interval of time the pair have made more than a complete revolution.

$\Omega = 100° \ 22'$ $\quad P = 23.65$ years
$\lambda = \ 72 \ \ 54$ $\quad T = 1892.67$
$\gamma = \ 78 \ \ 15$ $\quad a = 0''.633$
$e = 0.7298$

The following ephemeris is given:

t	P. A.	Dist.	t	P. A.	Dist.
	°	″		°	″
1913.0	76.3	0.30	1917.0	272.9	0.21
14.0	85.1	0.32	18.0	281.8	0.42
15.0	93.3	0.31	19,0	285.8	0.53
16.0	107.3	0.17	20.0	288.4	0.58

Orbits of the Spectroscopic Binaries *d* Tauri and 113 Herculis.—In the *Lick Observatory Bulletin* No. 226 Dr. Ralph E. Wilson gives the results of his computations of the orbits of the spectroscopic binary stars *d Tauri* ($\alpha = 4^h \ 30^m.2$; $\delta = + 9° \ 57'$) and 113 *Herculis* ($\alpha = 18^h \ 50^m.5$; $\delta = + 22° \ 32'$.) The former was announced as a binary by Moore in 1907 and the latter by Wright in 1900. Their magnitudes are 4.4 and 4.6 and their spectral classes A2 and G5, respectively. Thirty one spectrograms of *d Tauri* and thirty of 113 *Herculis* were available for measurement.

	Elements of *d Tauri.*	Elements of 113 *Herculis.*
Period	$P = 3.57124$ days	245.3 days
Gr. M.T. of Periastron	$T =$ J.D. $2419734.996 \pm .003$	2419805.0
Semi-amplitude of Radial Velocity	$K = 76.32 \pm 0.44$ km.	16.0 km.
Radial Velocity of System	$V_o = + 28.69 \pm 0.32$ km.	$- 23.2$ km.
Eccentricity	$e = 0.0$	0.12
Angle of Periastron from Node	$\omega =$	169°.5
Mean Daily Motion	$\mu = 100°.805$	1°.468
$a \sin i$	$= 3{,}748{,}000$ km	53,580,000 km.
$\frac{m_1^3 \sin^3 i}{(m + m_1)^2}$	$= 0.164 \odot$	$0.102 \odot$

A New Observatory is to be established in New Zealand. This has been made possible by the donation of $60,000 for this purpose by Thomas Cawthorn, of Nelson, New Zealand. The work of this observatory will be largely a study of solar physics. The idea of establishing an observatory in New Zealand to coöperate with other observatories throughout the world for the study of the sun was presented to the people of New Zealand by the daughter of the famous English astronomer Richard A. Proctor, Miss Mary Proctor, who went more than a year ago on a lecture tour to Australia.

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